TABLE OF CONTENTS

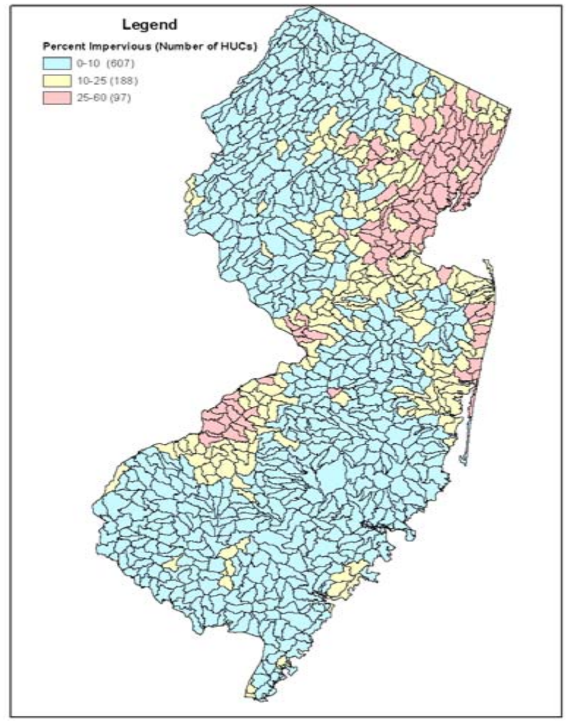
Increase in Impervious Surface 302
Invasive Plants -Exotic 316
  Asiatic Bittersweet 317
  Garlic Mustard 324
  Japanese Barberry 332
  Japanese Honeysuckle 338
  Japanese Stilt Grass 345
  Multiflora Rose 353
  Norway Maple 360
  Purple Loosestrife 367
  Tree-of-Heaven 374
Invasive Plants -Native 381
  Phragmites Australis 382
Lead (Organic and Inorganic) 391
Light Pollution 411
Mercury 418
MSX Parasite in Oysters 433
Nickel 443
Nitrogen Pollution (Water) 453
Noise 460
Noise (Boat-Recreational) 470
Off-road Vehicles (ORV) 475
Overharvesting (Marine) 478
Ozone (Ground Level) 490
Pesticides - Historical Use 495
Pesticides – Present Use 505
Petroleum Spills 540
Pets as Predators 551
Pfiesteria 557
Phosphorus 564

Issue: Increase in Impervious Surface
Author: Marjorie B. Kaplan, Dr. P.H.
Version: 02/24/01

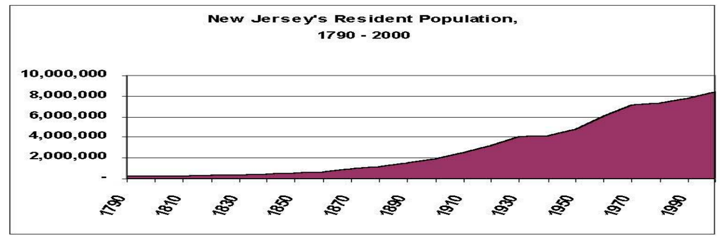
New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Increase in Impervious Surface**
Description of stressor	Impervious surface (IS) can be defined as any material that prevents infiltration of water into soil. Examples include roads, rooftops, sidewalks, blacktops, compacted soils and bedrock outcrops. The functional capacity of soil to retain water is impacted by IS. For some portion of IS in a watershed, runoff is routed directly to receiving streams. IS can increase the need for channelization. Alteration of natural hydrologic cycling impacts stream flow and receiving streams, affecting water quality, flood retention, water supply, habitat for aquatic and terrestrial species, and recreation. (Kaplan and Ayers 2000)
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Biological Integrity **Riparian vegetation alteration/loss; Habitat loss; Habitat degradation (loss of large woody debris); Forest Fragmentation; Increased riparian/streambank erosion; Increased sedimentation; Reduction in baseflow to streams; Increased flooding:** **All impact species assemblages, water quality, increase invasive species, seed and pathogen dispersal.** Biodiversity Species assemblages and increased invasive presence affected by impacts to biological integrity. Habitat/Ecosystem Health Habitat loss, Change in food supply/type, Sedimentation, Wetland Habitat Degradation, Increased local temperature, Flooding. All these affect water quality, impact the assemblage and health of species and species survival; fish and egg larval survival; altered aquatic ecology; altered flow regime. **Ecosystem Function** Flooding, Temperature Increases, Loss of Riparian Vegetation, Stream Baseflow Reductions, and Increase in Pollutant/Nutrient Loading impact aquatic and terrestrial species interactions, assemblages, species survival, larval stage survival; alter stream energy dynamics from heterotrophy to autotrophy. (Caraco et al. 1998; Wenger 1999; Arnold and Gibbons 1996; Reid 1993; Kaplan and Ayers 2000; Klein 1979; Schueler 1994; Stackelberg 1996; Stackelberg 1997; Allan 1995; Hicks 1995; Jones and Clark 1987; May 1997; O'Brien 1997a, 1997b)
Key impacts selected (critical ecological effects)	Biological Integrity Biodiversity Habitat/Ecosystem Health Ecosystem Function

Exposure Assessment	
Exposure routes and pathways considered	Habitat Loss, Erosion, Sedimentation, Flooding, Food Chain Uptake, Seed and Pathogen Dispersal, Increased Flow and Channelization, Temperature Change, Substrate Alteration, Turbidity.
Population(s)/ecosystem(s) exposed statewide	Aquatic, wetland, floodplain, and upland animal and plant species, including endangered and threatened species, that are water dependent and need water resources for survival, as well as species that will be adversely affected by increased human disturbances and activity represented by increases in impervious surfaces: developed land, road crossings, increased soil compaction. .



Quantification of exposure levels statewide	SOURCE: Ayers and Kauffman 2001 Data suggests that a strong relationship exists between percent impervious cover within a subwatershed unit and water quality, including biological diversity (Kaplan and Ayers 2000) Sensitive streams typically have a watershed impervious surface cover from 0-10%; impacted streams have a watershed impervious surface cover of 11-25%; and non-supporting streams cross a secondary threshold of greater than 25% impervious surface cover (Kaplan and Ayers 2000). A mapping analysis (shown above) has been conducted for NJ subwatersheds at the HUC-14* level (Ayers and Kauffman 2001). This analysis shows the distribution of the approximately 892 HUC-14 basins in New Jersey in relation to the threshold values established for benthic impairment and thoroughly reviewed in Kaplan and Ayers (2000). *Note: HUC-14 is a unique 14-digit identified for the smallest subwatershed drainage area, most ranging in size from 4.69-62.5 mi^2 delineated by an interagency (state and federal) committee for the purposes of cataloguing, tracking, monitoring, and regulating water data and water use in NJ. According to the impervious surface cover mapping analysis of Ayers and Kauffman (2001), approximately 68% of NJ's basins are below the 10% threshold, while, 21% are impacted, and 11% are non-supporting. This suggests that 32% or 1/3 of NJ's basins are already impacted by an average impervious surface cover above 10%. Impervious surfaces in this analysis are quantified in terms of roads and structures. Other sources of imperviousness (not quantified in this mapping analysis) include soil compaction which results from development, lawn maintenance, and forest management (Smith 2001; Hartman 2001; Arnold and Gibbons 1996). Therefore, additional quantification of exposure can be obtained by examining rate of development of NJ land. NJDEP estimates an 11% increase in urban land in NJ land between 1986 and 1995 based on digital aerial photography (Kaplan et al. 2001- in preparation). Assuming approximately 4,984,000 acres of land in New Jersey, this estimated development rate of 14,885 acres/year corresponds to approximately 0.3% of NJ land developed per year over the past 9 years. This value does not include land classified as barren land -- land that includes rock outcrops, sand and gravel pits, but also, can include land that is cleared at the time of overflight in preparation for building (Kaplan et al. 2001-in preparation, NJDEP 2000). In addition, NJDEP estimates a statewide net loss of the following land types between 1986 and 1995: 11.5% agricultural land; 2.4% forested land; and 1.4% of wetlands (Kaplan et al. 2001- in preparation).

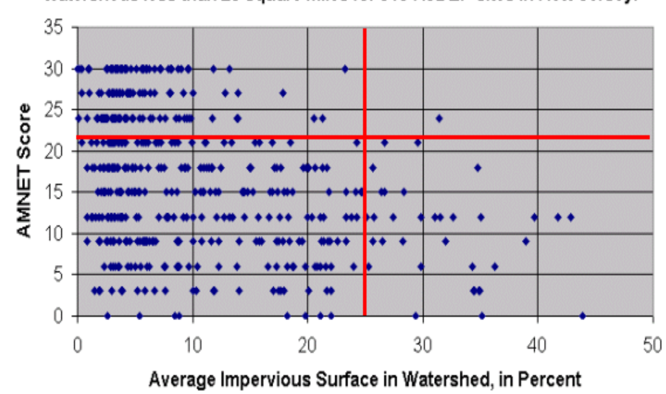


Specific population(s) at increased risk

Source U.S. Department of Commerce 2000

U.S. Department of Commerce data (2000) for New Jersey confirm that NJ's resident population continues to increase, rising to 8.4 million residents in 2000, an increase of approximately 68,000 persons/year between 1990 and 2000. It is reasonable to assume that land conversion will follow this trend. The current (2001) urban/built environment in New Jersey may be underestimated by the 1995 air photo based data and therefore, the impervious cover (as averaged by HUC-14 in this analysis) may be underestimated, as well.

All plant and animal species are at some risk from increased I.S.; however, rare plant and animal species are probably at greater risk. A qualitative assessment of populations at risk, follows. NJ is the most densely populated state in the U.S., while being one of the most ecologically diverse (Kaplan 1995). NJ stretches from the Ridge and Valley Landscape in the Northwest to the biologically unique Pinelands ecosystem of the Outer Coastal Plain. New Jersey has 2,215 known native plant species; approximately 36% of those are categorized as species of conservation concern; at danger of becoming increasingly rare or extinct. One percent (30 species) of plants have already been lost from the State (NJDEP 2001, in press). NJ is home to 90 species of mammals, 79 herptile species, and more than 400 species of fish. Approximately 325 species of birds inhabit NJ; 1.5 million shorebirds and 80,000 raptors make migratory stopovers in NJ. Approximately 7% or 63 of NJ's approximate 900 vertebrate species are threatened or endangered. Threat to the habitat of these species, such as impervious cover, including increased compaction of soil, increases risk to these populations. Of particular concern are endangered species such as swamp pink or bog turtles, that are directly impacted by increased imperviousness resulting from development. More specific impacts cited below.

Quantification of exposure levels to population(s) at increased risk	Not quantified at this time in terms of specific numbers of rare NJ species distributed in relation to IS. Torok (1994) demonstrated relationship between a stormwater outfall into bog turtle habitat and habitat alteration, vegetative community shift, altered hydrologic regimes, loss of seeps, and failure to confirm the presence of a previously known community of the endangered bog turtle, (*Clemmys muhlenberg)*, post development in Gloucester County, NJ. Johnson et al. (1998) documented a relationship between decreasing population size of the globally rare swamp pink (*Helonias Bullata)* and increased erosion, siltation, and scouring from residential and road crossing storm drains throughout Camden and Gloucester Counties, NJ.
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	**<u>Freshwater Systems and ISC in NJ</u>** Statewide, exposure levels are quantified by amount of impervious surface cover within a HUC-14 subwatershed (drainage average of 8.6 sq. mi. in NJ; range 2.3-42.0 sq. mi.). Threshold value of >10% IS considered to be impacted streams; secondary threshold value of >25% IS streams considered to be non-supporting of diverse animal community. Figure 1: The benthic invertebrate communities in all but one of the NJDEP AMNET sites in small watersheds (less than 20 mi^2) with an average impervious cover above 25% are moderately to severely impaired. AMNET scores of 21 or less indicate moderately impaired communities; severely impaired communities have scores of 9 or less. Figure 1. Relation of AMNET score to average impervious surface in watersheds less than 20 square miles for 510 NJDEP sites in New Jersey. 

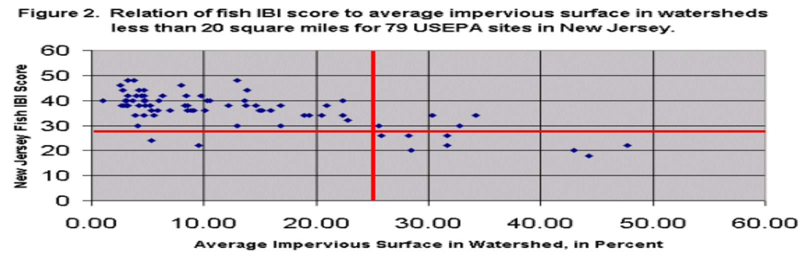


Figure 2. Fish IBI scores less than 28 indicate impaired fish communities. Fish IBI data for 79 sites in New Jersey from Kurtenbach (1993) plotted against average impervious surface cover at the subwatershed level show that eight of twelve sites above the 25% threshold of imperviousness are indeed of poor quality. The two sites indicating poor fish communities below the 25% threshold may be affected by additional factors such as point sources. Source: Kaplan and Ayers 2000.

The U.S. Geological Survey's Long Island-NJ component of the National Water Quality Assessment Program, reported that the major influences on stream quality for New Jersey and Long Island include: increased human activity/density and paved surface; increased surface runoff and chemical use; and decreased base flow, forested area and wetlands (Ayers et al. 2000). These factors directly and indirectly relate to increased IS. Environmental factors such as annual peak discharge, amount of impervious road area, and population density were statistically significantly related to impairment in fish, aquatic invertebrate, and algal communities in 36 streams in NJ and Long Island (Ayers et al. 2000). Impervious nonroad areas, such as stormwater pipes, were also related to negative impacts on aquatic invertebrate communities in the USGS study (Ayers et al. 2000).

Tidal and Marine Systems and ISC in NJ

Data for tidal waters is not inconsistent with fresh water systems. NJDEP (2000a) reports surface runoff from agricultural and developed lands, transported by direct stormwater discharges and tributary inputs, contribute to low Dissolved Oxygen (D.O.) conditions. An estimated 23.2% of assessed square miles of NJ estuarine water partially support aquatic life based on D.O.; while 76.8% of assessed estuarine waters have sufficient D.O. to support healthy biota (NJDEP 2000a). Assessment of near shore ocean waters found 21% fully supporting aquatic life, while 79% are assessed as threatened based upon D.O. levels (NJDEP 2000a). Among the multiple factors that EPA attributed to low D.O in near shore waters, were increased oxygen demand from sewage outfalls, river inputs, and stormwater runoff (NJDEP 2000a), all parameters that can be correlated with impervious cover.

Risk Characterization

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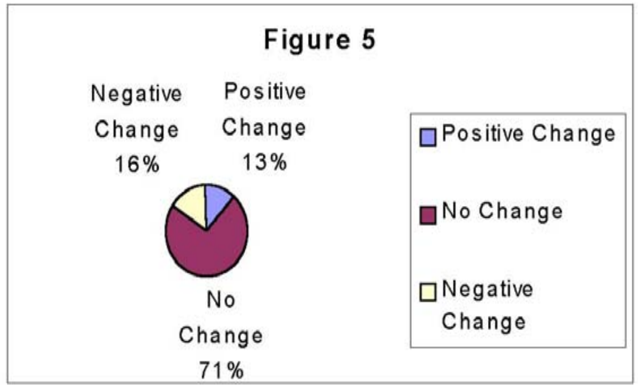
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	At least 1/3 of all species in NJ, animal and plant, are of conservation concern. Globally imperiled swamp pink and endangered bog turtles have been documented to be impacted by impervious cover in NJ. Statewide, 64.6% of assessed NJ waters are moderately or severely impaired benthic macroinvertebrate communities (NJDEP 1998). Approximately 0.3% (14,885 acres/year) of NJ land was developed per year between 1986 and 1995. Signs of reversal of these trends have not been measured; reversibility may not be possible for species already lost from NJ, recovery likely will be lenggthy from increased impervious cover even if removed or mitigated. Habitat restoration to predisturbance conditions is difficult (Sacco 2001).	4

Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	 Source: NJDEP 2000a. The above data correspond to the change in impairment score based upon benthic macroinvertebrate samples at 127 sites in the Upper Delaware Watershed of New Jersey. Originally sampled in 1993, the data indicate that overall, when resampled 5 years later (1998), about as many sites improved as declined in rating. (NJDEP 2000a). USGS has reported that total area of forest and wetland is best predictor of unimpaired benthic community and the amount of urban land in close proximity to sampling sites is best predictor of impaired benthic community. Other factors such as flow, sedimentation, local pollutant sources, etc. all contribute to impairment (NJDEP 2000a). The data shown above indicate that net improvements are not yet demonstrated in NJ.	4
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	1/3 NJ basins already have Impervious cover >10% threshold. 65% NJ waters are impaired.	4

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	Total	64
Assessment of uncertainties in this assessment (H,M,L) and brief description	Low: data for NJ show causal relationship between I.S.C. and benthic impairment with increased impervious cover, a well as direct impacts to other species such as bog turtles and swamp pink.	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	M Research underway to link benthic data with other aquatic species: fish, herptiles, odonates, mussels, and periphyton data. Should help refine analyses of sources and causes, whether can reverse trends remains to be determined.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, !, =, ≡; where + is improvement), and brief description.	0 Population and development pressures continue, planning area analyses underway show increased development in Environmentally Sensitive and Rural Planning Areas of New Jersey (Kaplan et al. 2001-in preparation)	
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	Low to Moderate: (potentially high to a specific species if last remaining population of such becomes extirpated from NJ by increased imperviousness)	
Link to other Work Groups (e.g., socioeconomic impacts)	<u>Human Health</u>: impacts to water supply (quantity) and water quality: drinking water as well as recreational exposure. Potential increase of human exposure to contaminants made bioavailable through sediment perturbances, as well as bacterial or viral exposure from flood-borne pathogens, as well as chronic runoff increases. <u>Socioeconomic</u>: Loss of Species for fishing or eating and potential increases in bioavailability of toxins for fish consumption. Recreational and tourism relationship: loss of recreational benefits from fishing, swimming lost because of increased contaminant loading, increased sediment loads or upwelling of sediments by high flows or flooding.	
Extent to which threat is currently regulated or otherwise managed	Moderately: CAFRA limits development in coastal areas; new stormwater rules will be for new development only; stream encroachment and wetlands permits only provide buffers to T&E species.	
Barriers to restoration	Land ownership; Lack of public education and understanding, lack of restoration plans, lack of suitable land for implementation of mitigative processes, lack of funds for overcoming these barriers.	
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources		
NJ Primary Sources		
Large business/industry	H	
Small business industry	H	
Transportation	H	
Residential	H	
Agriculture	M	

Recreation	M
Resource extraction	M
Government	M
Natural sources/processes	L
Orphan contaminated sites	L
Diffuse Sources	
Sediment sinks	NA
Soil sinks	NA
Non-local air sources incl. deposition	NA
Biota sinks	NA

Summary Statement:

Impervious surfaces are materials that prevent the functional capacity of water infiltration into soil, influencing natural hydrologic regimes, ground water recharge, stream flow, channelization, water quality and habitat alteration. All undeveloped lands, including riparian corridors, not currently under preservation, are at increased risk of future development and hence, impacted by increases in impervious surface cover. This risk threatens all immediate as well as downstream habitat with respect to recharge, baseflow to streams, and runoff. Primary and secondary impacts to wetlands, aquatic ecosystems, and rare species have already been documented for New Jersey. These effects may be irreversible or require a long time until theoretical recovery. Given the data presented, the fact that at least 1/3 of NJ's plant species are of conservation concern, 63 vertebrate species are threatened or endangered, that 65% of New Jersey's waters are impaired, that NJ's patterns of land development and population continue to follow similar patterns of growth, in urban, as well as environmentally sensitive and rural planning areas, the spatial and temporal patterns of this stressor are wide and expected to increase.

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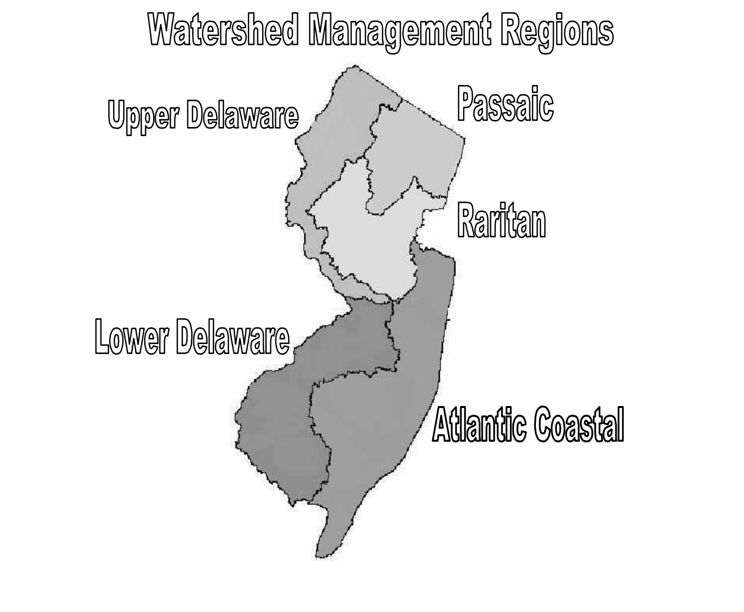
Statewide Analysis of Threat **Threat = Increase in Impervious Surfaces**

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	4	4	4	64
Marine Waters	4	4	4	64
Wetlands	4	4	5	80
Forests	4	4	4	64
Grasslands	3	5	3	45
			Total Score	317
			Average Score (Total ÷ 5)	63.4

Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	H	NA	H	H	M
Passaic	H	H	H	H	M
Raritan	H	H	H	H	M
Atlantic	H	H	H	H	M
Lower Delaware	H	H	H	H	M
Region/Watershed (secondary)					
Urban	H	H	H	H	M
Suburban	H	H	H	H	M
Rural	H	H	H	H	M

H=high, M=medium, L=low, NA = not applicable



REFERENCES

Allen, J.D. 1995. Stream Ecology. Structure and Function of Running Waters. London, UK: Chapman and Hall. (as cited in Wenger 1999).

Arnold, C.L. Jr. and C.J. Gibbons. 1996. Impervious Surface Coverage The Emergence of a Key Environmental Indicator. Journal of the American Planning Association 62(2): 243-258.

Ayers, M. and L. Kauffman. 2001. Impervious surface cover distribution for New Jersey Watersheds. West Trenton, NJ: USGS. Mapping Analysis prepared for M. Kaplan, NJDEP.

Ayers, M.A. , J.G. Kennen, and P.E. Stackelberg. 2000. Water Quality in Long Island-New Jersey Coastal Drainages, NY and NJ, 1996-98: U.S. Geological Survey circular 1201, 40 pp.

Caraco, D., R. Claytor, P. Hinkle, H. Kwon, T. Schueler, C. Swann, S. Vysotsky, and J. Zielinski. 1998. Rapid Watershed Planning Handbook. A Comprehensive Guide for Managing Urbanizing Watersheds. Prepared by Center For Watershed Protection, Ellicott City, MD. Prepared for U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds and Region V. October 1998.

Hartman, J.M. 2001. Personal Communication between Rutgers University Associate Professor of Landscape Architecture and Graduate Program in Ecology, Evolutionary Biology and Natural Resources, with Marjorie Kaplan, NJDEP, Division Science, Research and Technology. 10 January 2001.

Hicks, A.L. 1995. Impervious Surface Area and Benthic Macroinvertebrate Response as an Index of Impact from Urbanization on Freshwater Wetlands. M.S. Thesis, Department of Forestry and Wildlife Management, University of Massachusetts, Amherst, MA.

Johnson, E.A., T.F. Breden, and R.J. Cartica. 1998. Monitoring of *Helonia Bullata* populations in Camden and Gloucester Counties, New Jersey. Trenton, NJ: New Jersey Department of Environmental Protection. Division of Parks and Forestry, Office of Natural Lands Management.

Jones, R. and C. Clark. 1987. Impact on Watershed Urbanization on Stream Insect Communities. American Water Resources Association. Water Resources Bulletin.

Kaplan, M. 1995. Ecological Assessment: Ecosystem Management. Current Status and Implications for New Jersey. Trenton, NJ: NJ Department of Environmental Protection. 67 pp.

Kaplan, M. and M. Ayers. 2000. Impervious Surface Cover Concepts and Thresholds: Supporting Documentation for Water Quality and Watershed Management Planning Rules. Trenton, NJ: NJDEP. 10 pp.

Kaplan, M., J. Tash, E. Hahn, J. Tyrawski and L. Thornton. 2001 (DRAFT – in preparation). Land use land cover data for integrated land and natural resources watershed indicators. Trenton, New Jersey: New Jersey Department of Environmental Protection.

Klein, R. 1979. Urbanization and Stream Quality Impairment. American Water Resources Association. Water Resources Bulletin 15(4).

Kurtenbach, J. 1993. Index of biotic integrity study – New Jersey—Passaic, Wallkill, Delaware and Raritan drainages, summer 1990-1993. U.S. Environmental Protection Agency. 32 pp. plus app.

May, C.W., R.R. Horner, J.R. Karr, B.W. Mar, E.G. Welch. 1997. Effects of Urbanization on Small Streams in the Puget Sound Lowland Ecoregion. Watershed Protection Techniques 2(4): 483-493.

Maxted, J.T. and E. Shaver. 1998. The Use of Retention Basins to Mitigate Stormwater Impacts to Aquatic Life. Presented at National Conference on Urban Retrofit Opportunities for Water Resource Protection in Urban Areas, Chicago, IL, February 9-12, 1998.

New Jersey Department of Environmental Protection (NJDEP). 1998. Environmental Indicators Technical Report. Trenton, NJ: NJDEP. Water Resources p. 15-19.

New Jersey Department of Environmental Protection (NJDEP). 2000. DRAFT Environmental Indicators Technical Report, 2nd Edition, Land and Natural Resources Chapter. Trenton, NJ: NJDEP.

New Jersey Department of Environmental Protection (NJDEP). 2000a. DRAFT 2000 New Jersey Water Quality Inventory Report. Trenton, NJ: Division of Science, Research and Technology.

New Jersey Department of Environmental Protection (NJDEP). 2001. DRAFT State of the Environment Report (in preparation). Trenton, New Jersey.

O'Brien, A.K. 1997a. Presence and distribution of trace elements in New Jersey streambed sediments, U.S. Geological Survey Fact Sheet FS-049-97.

O'Brien, A.K. 1997b. Presence and distribution of trace elements in New Jersey streambed sediments, Journal of the American Water Resources Association, 33(2), p.387-403.

Reid, L. 1993. Research and Cumulative Watershed Effects. United States Department of Agriculture, Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-141.118 pp.

Sacco, John. 2001. Personal communication between Dr. Marjorie Kaplan, NJDEP, Division of Science, Research and Technology and John Sacco, Scientist, NJDEP Office of Natural Resource Damages. Trenton, NJ.

Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques 1(3): 100-111.

Smith, C. 2001. Personal Communication between USDA, NRCS, NJ District Office, Somerset, NJ and Marjorie Kaplan, NJDEP Division of Science, Research and Technology, 11 January 2001.

Stackelberg, P.E. , 1996, Presence and distribution of chlorinated organic compounds in New Jersey streambed sediments, U.S. Geological Survey Fact Sheet FS-118-96.

Stackelberg, P.E. , 1997, Presence and distribution of chlorinated organic compounds in New Jersey streambed sediments, Journal of the American Water Resources Association, 33(2), p. 271-284.

Torok, L.S. 1994. The impacts of stormwater discharges on an emergent bog community featuring a population of the bog turtles (*Clemmys Muhlenbergi*) in Gloucester County, New Jersey. Bull. Maryland Herpetological Soc. 30(2):51-61.

United States Department of Commerce. 2000. Resident Population and Historic Apportionment of the U.S. House of Representatives. Washington, D.C.: U.S. Census Bureau, Internet Release Date: December 28, 2000.

Wenger, S. 1999. A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation. Athens, GA: Institute of Ecology.

Zampella, R.A., R.G. Lathrop, J.A. Bognar, L.J. Craig, and K.J. Laidig.1994. A watershed-based wetland assessment method for the New Jersey Pinelands. New Lisbon, New Jersey: Pinelands Commission.

Issue: Invasive Plants-Exotic
Author:
Version:

Invasive Plants -Exotic

Issue: Asiatic Bittersweet *(Celastrus Orbiculatus)*
Author: Christopher Martine
Version: 03/27/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Asiatic Bittersweet** *Celastrus orbiculatus* Thunb. (Celastraceae) - (Gleason and Cronquist 1991)
Description of stressor	*C. orbiculatus* is a high climbing, woody, perennial, deciduous vine. Vines grow by twining around trees (Dirr 1990). Plants are dioecious or polygamo-dioecious (Gleason and Cronquist 1991). The range of Asiatic bittersweet in the United States is from Maine to Minnesota in the north, and Louisiana and Georgia in the south (Randall and Marinelli 1996). It inhabits moist open woods, woodland edges, stream banks, dunes, and roadsides (Hough 1983). The species has been used in horticulture since 1870 in the United States (Dirr 1990). It is native to Japan, Korea, and China where it is found in thickets and grassy slopes in lowlands and mountains (Ohwi 1965). Flowers are produced from early May - June and fruit ripen in September - October persisting through most of the winter (Hough 1983). Fruit are borne in axillary cymes and consist of a hard yellow outer cover over three orange arils (Gleason and Cronquist 1991). Additional information can be obtained from Dryer (1986) and Bergmann and Swearingen (1999). This species is very similar in appearance to the native *C. scandens*. The most reliable difference being the position of flowers/fruit, which is terminal in *C. scandens*.
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	The impacts of *C. orbiculatus* are derived from several factors: high reproductive output, widespread dispersal by birds (Wheeler 1987) and humans (Dreyer 1994), tolerance of low light conditions (Van Clef unpublished data) and strong response to increased light levels (Patterson 1975, Clement et al. 1991), ability to form dense monospecific stands through rapid growth and root suckering (Dreyer 1994), and a twining growth habitat that damages other woody vegetation via girdling (Lutz 1943). The above characteristics lead to various impacts on biodiversity and ecosystem health and function. High reproductive output and widespread dispersal ensure that all suitable habitats are at risk to infestation. Tolerance to low light conditions with the potential to form a seedling bank (Van Clef unpublished data) coupled with rapid acclimation in high light conditions places even closed forest communities at risk when disturbance occurs. In addition, its twining growth habit and rapid growth rates reduce tree regeneration and damages/kills mature trees by limb loss and increased tree blow-downs due to the weight of vine growth (Lutz 1943, Siccama et al. 1976, McNab and Meeker 1987). The rate of old-field succession can also be delayed by *C. orbiculatus* for the reasons mentioned above. The outcome can be a vine-scape where the return to closed forest is inhibited (Fike and Niering 1999, Siccama et al. 1976). The formation of dense monospecific stands leads to local reductions in abundance of native plants. Dense stands are particularly troubling when in close proximity to rare plant populations. The native *C. scandens* is especially at risk because of the preemption of suitable habitat by *C. orbiculatus* (Hough 1983). In addition, hybridization is possible between these species (White and Bowden 1947), which may act to swamp out the less abundant *C. scandens*.

Issue: Asiatic Bittersweet *(Celastrus Orbiculatus)*
Author: Christopher Martine
Version: 03/27/00

Key impacts selected (critical ecological effects)	Reduces abundance of native species. Reduces rate of old field succession. Increases disturbance in forests through damage to mature trees. Reduction of the native *C. scandens*.	
Exposure Assessment		
Exposure routes and pathways considered	Birds disperse fruit from established populations (Wheeler 1987) and horticultural plantings. Stems bearing fruit are often used in winter decorations, which aids long distance dispersal (Dreyer 1994).	
Population(s)/ecosystem(s) exposed statewide	All upland habitats outside of the central Pine Barrens (including coastal dune communities).	
Quantification of exposure levels statewide	Presence/absence data for *C. orbiculatus* in 25-km^2 blocks shows a widespread distribution in the New York metropolitan region (Clemants 1999).	
Specific population(s) at increased risk	The native *Celastrus scandens* is at risk through preemption of suitable habitat and possible hybridization. Rare plant populations in proximity to monospecific stands of *C. orbiculatus* are also at risk.	
Quantification of exposure levels to population(s) at increased risk	*C. scandens* populations have been rapidly disappearing in the metropolitan area (Clemants 1999), but direct cause and effect cannot be established.	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed	Fike and Niering (1999) compared adjacent successional areas that were abandoned at the same time (40 years ago). In areas infested with *C. orbiculatus* there was a large reduction 84%) in tree basal area (31.3 vs. 5.1 m^2/ha).	
Risk Characterization		
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly	*C. orbiculatus* can have varied and significant effects. The effects can only be reversed through coordinated removal followed by native plant restoration. This is not likely to be feasible on a large scale. Control methods are outlined in Dreyer (1986) and Ahrens (1987).	3

affected 1 - No detectable exposure		
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	*C. orbiculatus* is a ubiquitous part of the flora and future infestations are inevitable.	4
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted		2
	Total	24

Assessment of uncertainties in this assessment (H,M,L) and brief description	M: see data gaps below
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description. (Data Gaps; highlight significant data needs)	Rate of spread, quantification of impacts, hybridization potential with native *C. scandens* in wild populations, long-term monitoring of control methods.
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description.	++: Information on the rate of spread and quantification of impacts could alter this assessment. Prohibiting the sale of *C. orbiculatus* could reduce the spread of new populations.
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	L: Potential for short-term drastic impacts are low. However, further increases in abundance along with the hybridization potential could eventually lead to extinction of *C. scandens*.
Link to other Work Groups (e.g., socioeconomic impacts)	*C. orbiculatus* should no longer be sold for any purposes. Forestry can be affected when vine growth inhibits tree regeneration (McNab and Meeker 1987). Large trees can have reduced growth and increased limb loss/mortality due to heavy infestations.
Extent to which threat is currently regulated or otherwise managed	There are no regulations limiting the propagation and use of *C. orbiculatus*.
Barriers to restoration	There are many large and scattered populations over a wide geographical area making eradication nearly impossible. Efforts should be focused on eliminating newly forming infestations and eradicating infestations that are in proximity

	to rare species populations.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	H: Horticultural/Landscape - *C. orbiculatus* is still sold for residential landscape applications. In some cases, it is mistakenly sold as the native *C. scandens*.
Small business industry	H: horticultural/Landscape – see above
Transportation	M: Disturbance created by road maintenance, roadside mowing, and road creation favor *C. orbiculatus*.
Residential	M: There is continued spread from residential gardens. Individuals often collect fruiting branches for winter decorations thereby facilitating dispersal.
Agriculture	M: The maintenance of permanent woodland edges favors *C. orbiculatus*. Disturbances from normal farm operations supports weed establishment.
Recreation	M: Disturbance caused by off-road vehicles, heavy foot traffic, and other activities increases weed establishment.
Resource extraction	H: Disturbance caused by forestry, mining, etc. increases weed establishment.
Government	M: Unmanaged open space allows spread of *C. orbiculatus*.
Natural sources/processes	H: Established populations will continue to spread throughout the state.
Orphan contaminated sites	N/A
Diffuse Sources	
Sediment sinks	N/A
Soil sinks	L: Long-term seed banking ability is low. No seeds survived through two winters in forest habitat (Van Clef unpublished data).
Non-local air sources incl. Deposition	N/A
Biota sinks	N/A

Issue: Asiatic Bittersweet *(Celastrus Orbiculatus)*
Author: Christopher Martine
Version: 03/27/00

Statewide Analysis of Threat

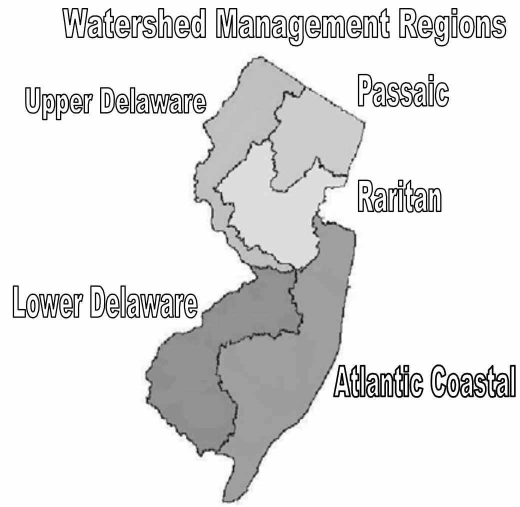
Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	N/A	N/A	N/A	N/A
Wetlands	3	4	3	36
Forests	3	4	4	48
Grasslands	3	4	3	36
			Total Score	120
			Average Score (Total ÷ 5)	24

Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	N/A	M	H	L
Passaic	N/A	N/A	M	H	L
Raritan	N/A	N/A	M	H	L
Atlantic	N/A	N/A	M	H	L
Lower Delaware	N/A	N/A	M	H	L
Region/Watershed (secondary)					
Urban	N/A	N/A	M	H	L
Suburban	N/A	N/A	H	H	M
Rural	N/A	N/A	H	H	M

H=high, M=medium, L=low, NA = not applicable

Issue: Asiatic Bittersweet *(Celastrus Orbiculatus)*
Author: Christopher Martine
Version: 03/27/00



References:

Ahrens, J.F. 1987. Herbicides for control of Oriental bittersweet. Northeast Weed Science Society Proceedings 41:167-170.

Bergmann, C. and J.M. Swearingen. 1999. Oriental bittersweet – Celastrus orbiculatus. Native Plant Alliance, Alien Plant Working Group, National Park Service. Document available at: http://www.nps.gov/plants/alien/fact/ceor1.htm

Clemants, S. 1999. New York metropolitan flora. Brooklyn Botanic Garden, New York.

Clement, C.R., R.S. Warren, G.D. Dreyer, and P.T. Barnes. 1991. Photosynthesis, water relations, and fecundity in the woody vines American and Oriental bittersweet (*Celastrus scandens* and *C. orbiculatus*). American Journal of Botany 78(supplement):134-135.

Dirr, M.A. 1990. Manual of woody landscape plants: their identification, ornamental characteristics, culture, propagation, and uses. Fourth Edition. Stipes Publishing Company, Champaign, Illinois.

Dreyer, G.D. 1986. Ecology and control of Oriental bittersweet and other weedy vines. Connecticut Arboretum, New London, Connecticut.

Dreyer, G.D. 1994. Element Stewardship Abstract for *Celastrus orbiculata* – Asiatic bittersweet. The Nature Conservancy, Arlington, Virginia.

Fike, J. and W.A. Niering. 1999. Four decades of old field vegetation development and the role of *Celastrus orbiculatus* in the northeastern United States. Journal of Vegetation Science 10:483-492.

Issue: Asiatic Bittersweet *(Celastrus Orbiculatus)*
Author: Christopher Martine
Version: 03/27/00

Gleason, H.A., and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. New York Botanical Garden, New York.

Hough, M.Y. 1983. New Jersey Wild Plants. Harmony Press. Harmony, New Jersey.

Lutz, H. 1943. Injury to trees caused by *Celastrus* and *Vitis*. Bulletin of the Torrey Botanical Club 70:436-439.

McNab, W.H. and M. Meeker. 1987. Oriental bittersweet: a growing threat to hardwood silviculture in the Appalachians. Northern Journal of Applied Forestry 4:174-177.

Ohwi, J. 1965. Flora of Japan. Smithsonian Institution Press, Washington, DC.

Patterson, D.T. 1975. Photosynthetic acclimation to irradiance in *Celastrus orbiculatus* Thunb. Photosynthetica 9:140-144.

Randall, J.M. and J. Marinelli. 1996. Invasive plants: weeds of the global garden. Brooklyn Botanic Garden Publications, New York.

Siccama, T.G., G. Weir, and K. Wallace. 1976. Ice damage in a mixed hardwood forest in Connecticut in relation to *Vitis* infestation. Bulletin of the Torrey Botanical Club 103:180-183.

White, O. and W. Bowden. 1947. Oriental and American bittersweet hybrids. Journal of Heredity 38:125-127.

Wheeler, L. 1987. Oriental bittersweet: avian dispersal in winter in relation to other species of fruiting plants. Undergraduate Individual Study Report. Zoology Department, Connecticut College, New London, Connecticut.

Issue: Garlic Mustard
Author: Tim Casey
Version: 03/27/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Garlic Mustard** (*Alliaria petiolata* (Beib.) Cavara and Grande)
Description of stressor	Invasive obligate biennial herb species of the Mustard family (Brassicaceae) from Europe of concern due to widespread geographic range expansion in the US and Canada. This species was first recorded in North America in 1868 in Long Island, NY. It has since spread exponentially in North America (Nuzzo, 1993). Considered an invasive species in nine other eastern states, Garlic mustard occurs in all physiogeographic provinces although it is less frequent in the Inner Coastal Plain (Kaufman and Snyder, 1999). *Alliaria* seeds germinate in early spring. By June seedlings develop characteristic rosette of first year plants. These rosettes are sensitive to summer draught (Byers, 1988). By mid fall surviving rosettes average 4-10 cm diameter. Rosettes continue to grow during snow free periods when temperatures are above freezing (Cavers et al, 1979). Natural mortality continues through winter. All plants surviving the winter produce flowers regardless of size and subsequently die. *Allairia* flowers can be self or cross-pollinated. Syrphid flies midges and bees visit the flowers and may effect pollination. Both in-bred and out-bred populations maintain substantial genetic variation (Byers and Quinn, 1998). Frequency of Alliaria increases over time doubling about ever four years on average. (Nuzzo, 1994). Frequently overlooked at low-density levels *Alliaria* populations can explode in favorable years. Greatest increases occur on sites exposed to large-scale natural disturbance. On a site experiencing a severe windstorm which blew down overstory trees, *Allaria* frequency increased 1000% two years later. On a site flooded in midsummer, frequency increased 241% during the same period. Garlic mustard invades forests in disturbances such as treefall and other disturbed habitat (trailside). Also prevalent and highly successful along streambanks and other disturbance sites. Until recently in New Jersey *Alliaria* was primarily associated with shaded river floodplain sites along the Delaware and Raritan rivers. More recently it can be found in drier sites some with full sun and in a range of sites associated with disturbance. The allocation of resources (biomass) to reproduction was greatest in the most disturbed sites (Byers and Quinn, 1998).
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health	Biological Integrity: High rates of seed production and lack of natural predators or parasites allows *Alliaria* to dominate the groundcover. Biodiversity:

Ecosystem function	Severe threat to native plants. Dense expanse of garlic mustard becomes virtually a monculture. Rapid spring growth (starting in late February in New Jersey) may be advantageous for outcompeting native spring ephemeral species. Ecosystem Function: Replacement of native species causes habitat diversity to be reduced. Garlic mustard is of no value as a food source for wildlife. Wildlife species which depend on these native species for their foliage, pollen, nectar fruits, seeds and roots are deprived of these essential food sources.	
Key impacts selected (critical ecological effects)	Loss of native species. Reduction in species diversity Decreased wildlife resources Loss of habitat	
Exposure Assessment		
Exposure routes and pathways considered	Anthropogenic distribution is the primary method of dispersal. Seeds are transported by natural area visitors on boots and in pants cuffs, pockets and hair, and by roadside mowing, trains and automobiles (Nuzzo, 1992). Seeds are widely dispersed in floodwater. Seeds may be dispersed by birds and rodents and whitetail deer although systematic studies are not available.	
Population(s)/ecosystem(s) exposed statewide	Wet to dry-mesic forest, and in partially shaded forest edges, river and stream banks, railroad and roadsides and other types of disturbed habitat including agriculture and suburban development (Byers and Quinn, 1998).*Alliaria* grows in sandy soil, loam and clay soils and on both limestone and sandstone substrates.	
Quantification of exposure levels statewide	Data not available for New Jersey	
Specific population(s) at increased risk	Many species of native ground dwelling plants. Significant infestations of *Alliaria may become* a monoculture and often do not allow other species to coexist. Populations of herbivorous insects and vertebrates that rely on native species may also be affected.	
Quantification of exposure levels to population(s) at increased risk	??	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed	These data are not currently available in New Jersey	
Risk Characterization		
Risk estimate(s) by population at risk		Score

Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	Garlic mustard causes serious damage to habitat and reduces biodiversity and food web structure. Management of habitat to prevent garlic mustard infestation is a long term and expensive proposition. Management: The goal is to prevent seed production until seeds stored in the soil are exhausted. Hand removal of plants is possible for light infestations when native species co-occur. At higher infestations the systemic herbicide glyphosphate should be applied. In many cases this will require subsequent replanting of desired species. Fire has been used to control garlic mustard in large natural setting but burning opens the understory	4
	encouraging germination of stored seed and promote growth of emerging garlic	

	mustard seedling. Burning schedules must continue for at least three to five years to ensure that seed stores have been exhausted.	
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Garlic mustard is common throughout New Jersey. There is a continuing threat to habitat from this species statewide.	4
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	Occurs in rich moist forest, floodplains and along trailsides and forest edges (Nuzzo, 1994). Due to the range of soil types, moisture and sun/shade tolerance, and preference for disturbed habitat garlic mustard is found throughout the state.	2
	Total	32
Assessment of uncertainties in this assessment (H,M,L) and brief description	**M:** Much data are available on *Alliaria,* from around the US and Canada. However few data are currently available for New Jersey populations.	
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description. (Data Gaps; highlight significant data needs)	H. Little quantitative data are currently available for this species. Virtually all information gathered would potentially be useful in preventing spread of Garlic mustard. Evaluate the role of whitetail deer in expansion of this species. Increases in deer result in removal of ground layer plants and disturb soil which could facilitate colonization by *Alliaria.*	

	Quantification studies on the rate of spread and impacts on native species populations are needed in New Jersey. Studies on recovery potential of invaded communities are needed: at what point is recovery not feasible or too expensive? (Nuzzo, 1994).
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description	(=) Byers and Quinn (1997) report that garlic mustard is expanding its range throughout New Jersey into new habitats shifting from wet, shady areas to new drier areas in full sun. Given the urban nature of New Jersey, large areas of land are disturbed and *Alliaria* thrives in such habitats. (++) Researchers in both Europe and the US are investigating four different potential biological control agents for garlic mustard, which could greatly improve our ability to control the spread of this species. The results of these trials should be complete within three years (V. Nuzzo, personal communication).
Potential for catastrophic impacts (H,M,L) and brief description	L
Link to other Work Groups (e.g., socioeconomic impacts)	*Alliaria* infestation may have economic consequences for the timber industry as it will compete with tree seedlings.
Extent to which threat is currently regulated or otherwise managed	No data available
Barriers to restoration	Communities should recover without assistance if *Alliaria* is removed before large populations develop. Few native species occur in dense infestations of *Alliaria* and recovery of heavily infested communities will require replanting. It appears that restoration of dense infestations is not cost effective. Premium should be placed on monitoring and management of land before garlic mustard can become firmly established. Due to long persistence of seeds in the seedbank (five years) eradication efforts will be long term on any managed site. Management of habitat already containing Alliaria thus will require long term management to insure that no seeds remain in the seedbank. Nuzzo, 1994).
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	L: Development activities cause disturbed habitat
Small business industry	L:
Transportation	M: Disturbed habitat associated with road construction and maintenance favors spread of *Alliaria.* Areas near railroad tracks are similarly attractive.
Residential	M: Development of sites for building and normal residential landscaping practices yield disturbed habitat.

Agriculture	M: Agricultural practices associated with normal farm operations produce disturbed habitat which favors spread.
Recreation	M: Disturbance caused by off road vehicles and heavy foot traffic and other activities can cause disturbed habitat favoring spread of *Alliaria*..
Resource extraction	M: Mining and forestry practices produce disturbed habitat.
Government	L: Unmanaged open space allows *Alliaria* to spread.
Natural sources/processes	H: Populations already well established around the state will continue to expand and colonize newly produced disturbed habitats.
Orphan contaminated sites	N/A
Diffuse Sources	
Sediment sinks	N/A
Soil sinks	*Alliaria* seeds persist in the seedbank for up to 5 years.
Non-local air sources incl. deposition	N/A
Biota sinks	N/A

Statewide Analysis of Threat

Threat = Invasive – Garlic mustard

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**	

Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	N/A	N/A	N/A	N/A
Wetlands	4	4	3	48
Forests	4	4	3	48
Grasslands	4	3	3	36
			Total Score	132
			Average Score (Total ÷ 5)	26.4

Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	N/A	H	H	M
Passaic	N/A	N/A	H	H	M
Raritan	N/A	N/A	H	H	M
Atlantic	N/A	N/A	H	H	M
Lower Delaware	N/A	N/A	H	H	M
Region/Watershed (secondary)					
Urban	N/A	N/A	H	H	M
Suburban	N/A	N/A	H	H	M-H
Rural	N/A	N/A	H	H	M-H

H=high, M=medium, L=low;

Literature cited

Byers, D.L. 1988. Life history variation of *Alliaria petiolata* in a range of habitats in New Jersey. M.S. thesis. Rutgers University, New Brunswick NJ. 132p.

Byers, D.L., J. A. Quinn 1998. Demographic variation in *Alliaria petiolata* (Brassicaceae) in four contrasting habitats. Bull Torrey Bot Club 125:138-149.

Cavers, P.B., M.I. Heagy and R.F. Kokron. 1979. The biology of Canadian weeds. 35. *Alliaria petiolata* (M. Bieb.) Cavara and Grande. Canadian Journal of Plant Science 59:217-229.

Kaufman, S. and D. Snyder (1999) Nonindigenous Invasive Plant Species of New Jersey. Draft Report to Division of Science, Research and Technology, NJDEP.

Meekins, J.F. and B. C. McCarthy 1999. Competitive ability of *Alliaria petiolata* (garlic mustard, Brassicaceae), an invasive nonindigenous forest herb. Int. J. Plant Sci. 160(4):743-752.

Nuzzo, V.A. 1991. Experimental control of garlic mustard [*Alliaria petiolata* (Bieb.) Cavara and Grande] in northern Illinois using fire, herbicide, and cutting. Nat. Areas J. 11:158-167.

Nuzzo, V.A. 1993. Distribution and spread of the invasive biennial garlic mustard (*Alliaria petiolata*) in North America. Pp 137-146 in McKnight, B.N., editor Biological Pollution: the control and impact of invasive exotic species; proceedings of a symposium held at the Indiana University-Purdue University October 25 & 26, 1991. Indiana Academy of Science. Indianapolis IN. 261p.

Nuzzo, V.A. 1994. Element stewardship abstract for *Alliaria petiolata* (*Alliaria officinalis*) Garlic Mustard. http://tncweeds.ucdavis.edu/esadocs/documnts/allipet.rtf

Issue: **Japanese Barberry**
Author: Tim Casey
Version: 03/27/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	**Findings**
Hazard Identification	
Stressor	**Japanese Barberry** (Berberis thunbergii DC)
Description of stressor	Woody deciduous shrub with dense spiny branches. Commonly growing 2 to 3 ft tall it occasionally up to 6 ft. Plants consist of multiple stems originating from a root collar, plus shoots arising from stolons and/or rhizomes within one to several decameters ??? (dm) of the roots. Shoots also arise from the rooting of long stems which touch the ground at some distance (1-2 m) from the root base (Ehrenfeld, 2000). Simple rounded leaves form rosettes along the branches in an alternate pattern. It produces solitary or small clusters of yellow flowers along the stem in spring and the fruits ripen to a bright red oblong berry in late summer.
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Biodiversity: thickets of Japanese Barberry in forests with closed canopies adversely affects biomass of co-occurring native species (Silander and Klepeis, 2000). This may have adverse effects on birds and other animals dependent on the native vegetation. Ecosystem function: Stands of barberry cause changes in soil properties including higher pH and the organic horizon is missing (Kourtev et al, 1998). Further studies suggest available nitrate and net potential nitrification were significantly higher in the soil. Significantly higher earthworm densities occur in soil under Barberry plants compared to native species (Kourtev et al, 2000).
Key impacts selected (critical ecological effects)	Biodiversity and ecosystem function.
Exposure Assessment	
Exposure routes and pathways considered	Seeds are dispersed by birds and mammals that eat the bright red oblong berries. It is commonly planted as an ornamental shrub.
Population(s)/ecosystem(s) exposed statewide	Forests, streams and roadsides are all potential areas of invasion. Due to its use as an ornamental shrub new sources of invasion can occur anywhere in the state.
Quantification of exposure levels statewide	Considered an invasive species in at least nine Eastern states, Barberry invades deciduous forests particularly in central and northern New Jersey and New York (Ehrenfeld, 1997). It often grows along forest edges and in disturbed areas. It also can invade deep into forests with closed canopies as a result of its ability to grow at low light levels as well as in full sun. It also occurs in Burlington, Cape May, Camden, Gloucester and Monmouth Counties. It is common throughout all the physiographic regions of New Jersey (Kaufman and Snyder, 1999).
Specific population(s) at increased risk	Native plant species in forests and other areas where dense thickets of Barberry develop.

Issue: **Japanese Barberry**
Author: Tim Casey
Version: 03/27/00

Quantification of exposure levels to population(s) at increased risk	No data for New Jersey
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	Ehrenfeld (1997) conducted a survey of forested areas in central and northern NJ. Her data show that the plant is present within the forest interior in at least 43 protected forest areas. In the majority of these areas *B. thunbergii* occurs in extensive patches of moderate to very high density. The spread of this species into intact forest had not previously been reported.
Risk Characterization	
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude) Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	Adverse effects on ecosystem processes and native species in close proximity to thickets.Changes in soil properties, especially changes in nitrogen cycling associated by invading Barberry may permit invasion of other weedy or exotic species. Restoration of the native flora might be inhibited by the high nitrate concentrations in the soil (Kourtev et al, 2000). Recovery of native vegetation after Barberry removal is slow except at very high light levels (Silander and Klepeis, 2000). Control methods include mechanical removal of the plants via hand pulling. Mowing / cutting will control the spread of Barberry but will not eradicate it. Herbicidal control: 2% solution of glyphosphate and water plus surfactant to thoroughly wet all leaves. Glyphosphate is a non-selective systemic herbicide that may kill non-target partially sprayed plants. In areas where desirable grasses are growing under or around Japanese barberry, triclopyr (2% solution in water plus surfactant) can be used without non target damage.

Issue: **Japanese Barberry**
Author: Tim Casey
Version: 03/27/00

Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	As a result of little or no control methods being applied the threat of Barberry invasion is increasing. Seed production is greatest in large plants and well established areas of Barberry throughout the state are providing an ever increasing source for new invading plants.	4
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	Difficult to estimate due to a lack of detailed census of the state.	2-3
	Total	24-36
Assessment of uncertainties in this assessment (H,M,L) and brief description	Medium (M): see data gaps below	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	Medium (M): Rate of spread and quantification of impacts are needed. Information on long-term monitoring and native species recovery after removal of Barberry are lacking. Mounting control and long-term monitoring programs are needed. Information on the rate of spread and quantification of impacts could alter this assessment. Some of the best data available for this species has recently been published by Rutgers scientists (J.G. Ehrenfeld, Peter Kourtev). Further work (if funded) by this group would add valuable new information.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, !, =, ≡; where + is improvement), and brief description.	(-) Continuation of sale of nursery stock as an ornamental shrub will increase its presence in the State. In addition, the threat is increasing because more plants are available to provide increased amounts of seed for dispersal.	
Potential for catastrophic impacts (H,M,L) and brief description	L: No evidence to date suggests the potential for catastrophic impacts to ecosystems.	
Link to other Work Groups (e.g., socioeconomic impacts)	*B. thunbergii* should not be sold for any purpose.	
Extent to which threat is currently regulated or otherwise managed	There are currently no regulations limiting the propagation and uses of Barberry in New Jersey.	
Barriers to restoration	Changes in soil properties, especially changes in nitrogen cycling associated by invading Barberry may permit invasion of other weedy or exotic species. Restoration of the native flora might be inhibited by the high nitrate concentrations in the soil (Kourtev et al, 2000). Recovery of native vegetation after Barberry removal is slow except at very high light levels (Silander and Klepeis, 2000).	
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources		

Issue: **Japanese Barberry**
Author: Tim Casey
Version: 03/27/00

include any information/details on sources	
NJ Primary Sources	
Large business/industry	H Nursery industry still sells this species as a commercial ornamental shrub for landscaping applications.
Small business industry	H Horticultural/Landscape – see above
Transportation	M Roadside creation, maintenance and mowing provide favorable habitat for *B. thunbergii*
Residential	M Use of *B. thunbergii* as a landscape plant provides new sources of invasion
Agriculture	M. The maintenance of permanent woodland edges favors *B. thunbergii.*
Recreation	M. Disturbance caused by off road vehicles, heavy foot traffic, and other activities increases weed establishment.
Resource extraction	L
Government	M Unmanaged open space allows spread of *B. thunbergii*
Natural sources/processes	H Established populations will continue to spread throughout the state.
Orphan contaminated sites	N/A
Diffuse Sources	
Sediment sinks	N/A
Soil sinks	M(?) Seed bank. Data are not currently available on the long term survival of seed in the seed bank.
Non-local air sources incl. deposition	N/A
Biota sinks	N/A

Issue: **Japanese Barberry**
Author: Tim Casey
Version: 03/27/00

Summary Statement:

(This statement should include a brief description of the stressor, exposure pathway(s), populations/ecosystems exposed, effects/impacts, and reason for the score given).

Statewide Analysis of Threat Threat = Invasive species - Japanese Barberry

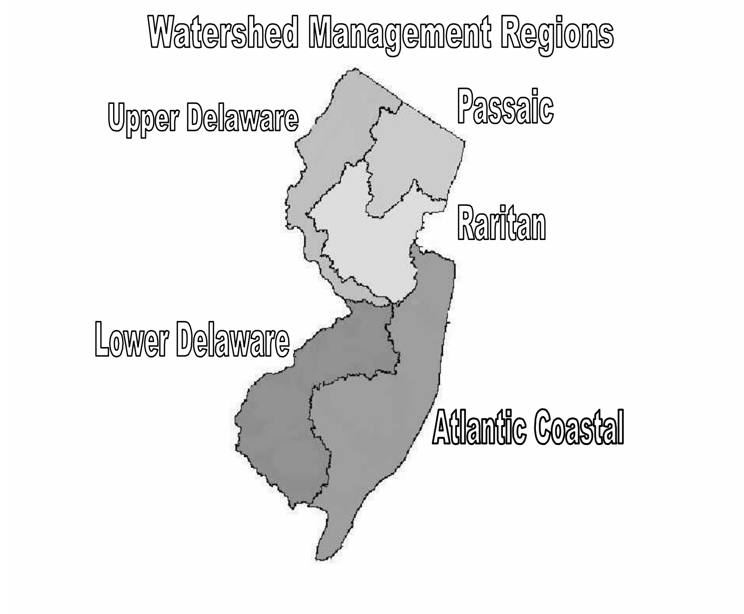
Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	N/A	N/A	N/A	N/A
Wetlands	3	3	3	27
Forests	3	4	3	36
Grasslands	3	2	3	18
			Total Score	81
			Average Score (Total ÷ 5)	16.2

Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	NA	M	H	L-M
Passaic	N/A	N/A	M	H	L-M
Raritan	N/A	N/A	M	H	L-M
Atlantic	N/A	N/A	M	H	L-M
Lower Delaware	N/A	N/A	M	H	L-M
Region/Watershed (secondary)	N/A	N/A	M	H	L-M
Urban	N/A	N/A	M	H	L-M
Suburban	N/A	N/A	M	H	L-M
Rural	N/A	N/A	M	H	L-M

H=high, M=medium, L=low, NA = not applicable

Issue: **Japanese Barberry**
Author: Tim Casey
Version: 03/27/00



Literature cited

Ehrenfeld, J. (2000). Structure and dynamics of populations of Japanese Barberry (*Berberis thunbergii* DC.) in deciduous forests of New Jersey. Biological Invasions 1: 203-213.

Ehrenfeld, J. (1997). Invasion of deciduous forest preserves in the New York metropolitan region by Japanese Barberry *(Berberis thunbergii* DC.) Journal of the Torry Botanical Society 124(2) 210-215.

Kaufman, S. and D. Snyder (1999) Nonindigenous Invasive Plant Species of New Jersey. Draft Report to Division of Science, Research and Technology, NJDEP.

Kourtev, P., J.G. Ehrenfeld and W. Huang (1998). Effects of exotic plant species on soil properties in hardwood forests of New Jersey. Water, Air and Soil Pollution 105: 493-501.

Kourtev, P.S., W.Z. Huang and J.G. Ehrenfeld (2000). Differences in earthworm densities and nitrogen dynamics in soils under exotic and native plant species. Biological Invasions 1: 237-245.

Silander, J.A. and D. M Klepeis (2000). The invasion ecology of Japanese Barberry (*Berberis thunbergii*) in the New England landscape. Biological Invasions 1: 189-201.

Issue: Japanese honeysuckle
Author: Tim Casey
Version: 03/27/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Japanese Honeysuckle** *Lonicera japonica* Thunb. (Caprifoliaceae) – (Gleason and Cronquist 1991)
Description of stressor	*Lonicera japonica* is a high-climbing and/or trailing, semi-evergreen to evergreen, woody vine. Vines climb by twining around their host. It is native to Japan, China, and Korea and was introduced to North America as a horticultural plant in 1806 (Dirr 1990). The range of *L. japonica* in the United States is from Massachusetts west to Illinois and Missouri, and south to Kansas, Texas, and Florida (Randall and Marinelli 1996). It inhabits fields, roadsides, woodland edges, disturbed woodlands, and floodplain forests (Hough 1983, Nuzzo 1997). Flowers are produced from May to July and fruit ripen from September to November (Hough 1983), persisting on the vine through winter. Additional descriptive information can be found in Nuzzo (1997).
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	The impacts of *L. japonica* are derived from several factors: high reproductive output, widespread dispersal by birds and humans, tolerance of low light conditions, ability to form dense monospecific stands through rapid growth and vegetative spread, and a twining growth habitat that damages other woody vegetation via girdling. The above characteristics lead to various impacts on biodiversity and ecosystem health and function. High reproductive output and widespread dispersal ensure that all suitable habitats are at risk to infestation. Indirect evidence suggests that *L. japonica* cannot persist indefinitely under closed canopy conditions (Robertson et al. 1994, Nuzzo 1997). However, it does display some tolerance to low light conditions and even closed forest communities are at risk, especially following disturbance of the canopy (Slezak 1976). Its evergreen habit, along with giving it a competitive advantage by increasing its growing season (Bell et al. 1988, Schierenbeck and Marshall 1993), places spring ephemeral herbs at risk by casting shade before tree canopy leaf out. *L. japonica* can alter the dynamics of canopy gap closure and creates opportunities for invasion of other non-native species (Slezak 1976). In high light conditions, its twining growth habit and rapid growth rates reduce tree regeneration and damages/kills young woody vegetation. *L. japonica* can also impact the composition of successional perennial herb communities in New Jersey (Myster and Pickett 1992). The rate of old-field succession can be delayed by *L. japonica.* The outcome can be a honeysuckle "disclimax" (Hardt 1986). Studies have shown that intense root competition slows the growth of trees allowing honeysuckle to more easily smother vegetation (Whigham 1984, Dillenberg et al. 1993a, 1993b, 1995). The formation of dense monospecific stands leads to local reductions in abundance of native plants. Dense stands are particularly troubling when in close proximity to rare plant populations.
Key impacts selected (critical ecological effects)	Reduces abundance of native species. Reduces rate of old field succession. Reduces forest canopy gap closure dynamics. Reduces abundance of forest understory herbs.
Exposure Assessment	

Exposure routes and pathways considered	Birds disperse fruit from established populations and horticultural plantings (Nuzzo 1997). *L. japonica* exhibits strong vegetative growth, which allows it to grow vertically up woody vegetation and horizontally along the ground (rooting at leaf nodes).	
Population(s)/ecosystem(s) exposed statewide	All upland habitats outside of the central Pine Barrens are at risk to infestation.	
Quantification of exposure levels statewide	Presence/absence data for *L. japonica* in 25-km^2 blocks shows a widespread distribution in the New York metropolitan region (Clemants 1999). The species has a more limited distribution south of Monmouth County (Hough 1983).	
Specific population(s) at increased risk	Understory herbs are especially at risk. Any rare plant populations in proximity to dense monospecific stands are also at risk.	
Quantification of exposure levels to population(s) at increased risk	There is no quantification of effects of *L.* on understory herbs or rare plants.	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed	There are no studies quantifying community-level effects of *L. japonica*.	
Risk Characterization		
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	*L. japonica* can have varied and significant effects. The effects can only be reversed through coordinated removal followed by native plant restoration. This is not likely to be feasible on a large scale. Control methods including the use of prescribed burns and herbicides are outlined in Barden and Mattews (1980) and Nuzzo (1997).	3

Issue: Japanese honeysuckle
Author: Tim Casey
Version: 03/27/00

Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	*L. japonica* is a ubiquitous part of the flora and future infestations are inevitable.	4
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	Presence/absence data and personal observations indicate that this species can be found in all physiographic regions of the state. Dense populations are more local in distribution.	3
	Total	36
Assessment of uncertainties in this assessment (H,M,L) and brief description	M: see data gaps below	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	H: Rate of spread, quantification of impacts, seed bank longevity, long-term monitoring of control methods.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description.	++: Information on the rate of spread and quantification of impacts could alter this assessment. Prohibiting the sale of *L. japonica* could reduce the spread of new populations.	
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	L: The potential for short-term drastic impacts is low. However, over the longer term, understory herbs and rare plant populations are at risk.	
Link to other Work Groups (e.g., socioeconomic impacts)	*L. japonica* should no longer be sold for any purposes. Forestry can be affected when vine growth inhibits tree regeneration, especially if it is present at the time of harvest (Slezak 1976). Two years of root and shoot competition from *L. japonica* reduced the growth of young *Liquidambar styraciflua* trees (DBH, 43% reduction; height, 36% reduction) (Dillenberg et al. 1993a). Mature trees can also be at risk from *L. japonica* if other vines are present because it may "ladder" into the tree canopy (Hardt 1986).	
Extent to which threat is currently regulated or otherwise managed	There are no regulations limiting the propagation and use of *L. japonica*.	

Issue: Japanese honeysuckle
Author: Tim Casey
Version: 03/27/00

Barriers to restoration	There are many large and scattered populations over a wide geographical area making eradication nearly impossible. Efforts should be focused on eliminating newly forming infestations and eradicating infestations that are in proximity to rare species populations.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	H: Horticultural/Landscape - *L. japonica* is still sold for residential landscape applications.
Small business industry	H: Horticultural/Landscape – see above
Transportation	M: Disturbance created by road maintenance, roadside mowing, and road creation favor *L. japonica*.
Residential	M: There is continued spread from residential gardens.
Agriculture	M: The maintenance of permanent woodland edges favors *L. japonica*. Disturbances from normal farm operations supports weed establishment.
Recreation	M: Disturbance caused by off-road vehicles, heavy foot traffic, and other activities increases weed establishment.
Resource extraction	H: Disturbance caused by forestry, mining, etc. increases weed establishment.
Government	M: Unmanaged open space allows spread of *L. japonica*.
Natural sources/processes	H: Established populations will continue to spread throughout the state.
Orphan contaminated sites	N/A
Diffuse Sources	
Sediment sinks	N/A
Soil sinks	The soil seed bank dynamics of *L. japonica* are unknown.
Non-local air sources incl. deposition	N/A
Biota sinks	N/A

Issue: Japanese honeysuckle
Author: Tim Casey
Version: 03/27/00

Statewide Analysis of Threat

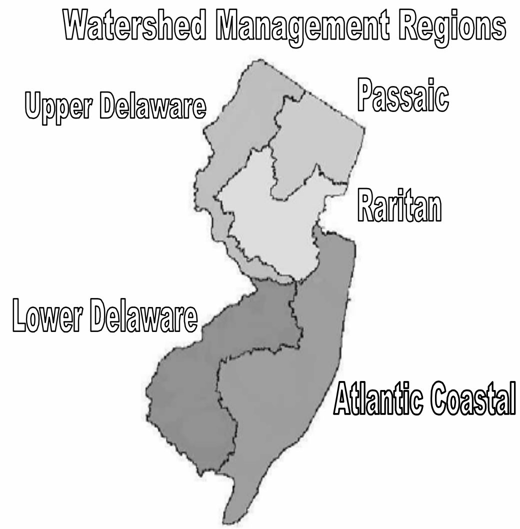
Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	N/A	N/A	N/A	N/A
Wetlands	3	4	3	36
Forests	3	5	4	60
Grasslands	3	3	2-3	18-27
			Total Score	114-123
			Average Score (Total ÷ 8)	22.8-24.6

Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	N/A	M-H	H	M
Passaic	N/A	N/A	M-H	H	M
Raritan	N/A	N/A	M	H	M
Atlantic	N/A	N/A	M	M-H	M
Lower Delaware	N/A	N/A	M	M-H	M
Region/Watershed (secondary)					
Urban	N/A	N/A	M	H	M
Suburban	N/A	N/A	M	H	M
Rural	N/A	N/A	M	H	M

H=high, M=medium, L=low, NA = not applicable

Issue: Japanese honeysuckle
Author: Tim Casey
Version: 03/27/00



References:

Barden, L.S. and J.F. Matthews. 1980. Change in abundance of honeysuckle (*Lonicera japonica*) and other ground flora after prescribed burning of a piedmont pine forest. Castanea 45:257-260.

Bell, D.J., I.N. Forseth, and A.H. Teramura. 1988. Field water relations of three temperature vines. Oecologia 74:537-545.

Clemants, S. 1999. New York metropolitan flora. Brooklyn Botanic Garden, New York.

Dillenberg, L.R., D.F. Whigham, A.H. Teramura, and I.N. Forseth. 1993a. Effects of below- and aboveground competition from the vines *Lonicera japonica* and *Parthenocissus quinquefolia* on the growth of the tree host *Liquidambar styraciflua*. Oecologia 93:48-54.

Dillenberg, L.R., D.F. Whigham, A.H. Teramura, and I.N. Forseth. 1993b. Effects of vine competition on availability of light, water, and nitrogen to a tree host (*Liquidambar styraciflua*). American Journal of Botany 80:244-252.

Dillenberg, L.R., A.H. Teramura, I.N. Forseth, and D.F. Whigham. 1995. Photosynthetic and biomass allocation responses of *Liquidambar styraciflua* (Hamamelidaceae) to vine competition. American Journal of Botany 82:454-461.

Dirr, M.A. 1990. Manual of woody landscape plants: their identification, ornamental characteristics, culture, propagation, and uses. Fourth Edition. Stipes Publishing Company, Champaign, Illinois.

Issue: Japanese honeysuckle
Author: Tim Casey
Version: 03/27/00

Gleason, H.A., and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. New York Botanical Garden, New York.

Hardt, R.A. 1986. Japanese honeysuckle: from "one of the best" to ruthless pest. Arnoldia 46:27-34.

Hough, M.Y. 1983. New Jersey Wild Plants. Harmony Press. Harmony, New Jersey.

Myster, R.W. and S.T.A. Pickett. 1992. Dynamics of associations between plants in ten old fields during 31 years of succession. Journal of Ecology 80:291-302.

Nuzzo, V. 1997. Element Stewardship Abstract for *Lonicera japonica* – Japanese Honeysuckle. The Nature Conservancy, Arlington, Virginia. Last Update: 15 April 1997.

Randall, J.M. and J. Marinelli. 1996. Invasive plants: weeds of the global garden. Brooklyn Botanic Garden Publications, New York.

Robertson, D.J., M.C. Robertson, and T. Tague. 1994. Colonization dynamics of four exotic plants in a northern Piedmont natural area. Bulletin of the Torrey Botanical Club: 121:107-118.

Schierenbeck, and J.D. Marshall. 1993. Seasonal and diurnal patterns of photosynthetic gas exchange for *Lonicera sempervirens* and *L. japonica* (Caprifoliaceae). American Journal of Botany 80:1292-1299.

Slezak, W.F. 1976. *Lonicera japonica* Thunb., an aggressive introduced species in a mature forest ecosystem. M.S. Thesis. Rutgers University, New Brunswick, NJ.

Whigham, D.F. 1984. The influence of vines on the growth of *Liquidambar styraciflua* L. (sweetgum). Canadian Journal of Forest Resources 14:37-39.

Issue: Japanese Stilt Grass
Author: Tim Casey
Version: 03/27/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Japanese Stilt Grass** *Microstegium vimineum* (Japanese Wire Grass, Eulalia)
Description of stressor	A straggling annual grass, up to 1 m long, frequently decumbent and rooting at the lower nodes. Leaves are cauline, lanceolate, 5-10 cm long, 2-15 mm wide, usually with a faintly reflective stripe of hairs along the midvein on the upper surface of the leaf. The flowers bloom on delicate exerted spikes and in axillary cleistogamous spikes in the late summer and fall. Seeds mature mid- to late fall. (Barden 1991, Swearingen 1999, Kaufman and Snyder 1999, M. Palmer, personal observation)
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Biological integrity: *Microstegium* can form dense mats on floodplains and other mesic soils, which outcompete native herbaceous vegetation. (Kaufman and Snyder 1999, Swearingen 1999) Biodiversity: Sites with dense *Microstegium* populations suffer a reduction in diversity (D. Snyder, pers. comm.). The changes that *Microstegium* effects in the soil environment may also negatively impact diversity (Kourtev et. al. 1998). Habitat/ecosystem health: Dense lawns of *Microstegium* replace open, more diverse herbaceous communities, particularly on floodplains. The replacement of diverse communities with single-species stands negatively affects both habitat diversity and ecosystem stability. Ecosystem function: The invasion of a site by *Microstegium* may be accompanied by the invasion of exotic earthworms (see Kourtev et. al. 1998). Soils under a dense stands of *Microstegium* have a thinner litter layer, a higher pH, and a thinner organic soil horizon when compared to soils under stands of native vegetation (Kourtev et. al. 1998). Changes in the soil associated with the invasion of *Microstegium* almost certainly has an effect on the soil food web and nutrient cycling, but these impacts are not yet documented.
Key impacts selected (critical ecological effects)	*Microstegium* invasions replace diverse, open herbaceous communities with dense, monospecific lawns. *Microstegium* invasion is associated with changes in the soil that may fundamentally affect control and/or restoration.

Exposure Assessment	
Exposure routes and pathways considered	As an annual grass (note that the report of a perennial form [Ehrenfeld 1999] is likely erroneous and based on a misidentification), *Microstegium* is largely dependent on recruitment from seed. Individual patches can spread as a result of stems rooting at the nodes, but this is a slower and secondary exposure route (Swearingen 1999, Barden 1987) Seed dispersal vectors for *Microstegium* are largely unstudied. The seeds are known to be dispersed via streams and floods (which explains the species' abundance in riverine habitats), but other vectors are uncertain (Woods and Ashburn 1989, Barden 1991, Tennessee 2000). Transport via the fur of animals (Woods and Ashburn 1989) and in the transport of hay, fill dirt, and in the soil of container grown nursery plants have all been suggested (Barden 1991, D. Snyder pers. comm.). The seeds of *Microstegium* remain viable in the soil for at least three years. A single plant is capable of producing 100-1000 seeds in a year, and plants that are damaged in the early season may produce seeds in a second flush of growth (Barden 1991). *Microstegium* establishes most quickly on disturbed sites, particularly those disturbed by flood related scouring and moving (Barden 1987, Barden 1991). On fertile sites, *Microstegium* can outcompete other vegetation within 3-5 years (Barden 1987, Tennessee 2000). In undisturbed vegetation, the spread of *Microstegium* is much slower (Barden 1987). *Microstegium* is capable of significant growth and seed production under shady conditions (Winter et. al. 1982).
Population(s)/ecosystem(s) exposed statewide	In New Jersey, *Microstegium* is most common along streams, ditches, and canals (Kaufman and Snyder 1999). The preferred soils characteristics are moist, acidic to neutral, and high in nitrogen (Swearingen 1999). *Microstegium* is most abundant in the red clay soils of the Piedmont, which is true both in New Jersey (D. Snyder, pers. comm.) and throughout the species' range (Hunt and Zaremba 1992). The species can tolerate a broad range of light and moisture conditions, and is found in habitats ranging from wetlands to successional fields to forested uplands (Hunt and Zaremba 1992).
Quantification of exposure levels statewide	*Microstegium* is increasing in frequency in New Jersey at an alarming rate (D. Snyder, pers. comm.). *Microstegium* was first collected in North America in Tennessee in 1919 and was first collected in New Jersey in 1959 (Fairbrothers and Gray 1972). Since that time, *Microstegium* has spread to all the counties of New Jersey (with the possible exception of Sussex and Cape May Counties, though a systematic search would probably locate the species everywhere) and is especially abundant in the Piedmont provinces (Hough 1983, D. Snyder pers. comm.). The abundance of this species in New Jersey is almost certainly underreported (see Redman 1995, Hunt and Zaremba 1992).

Issue: Japanese Stilt Grass
Author: Tim Casey
Version: 03/27/00

Specific population(s) at increased risk	Any non-invaded riparian habitat in the Piedmont provinces will almost certainly become invaded in the near future. Rare plants that grow in riparian areas or require disturbance at a increased risk, as these are the conditions under which *Microstegium* grows most vigorously and abundantly (Kaufman and Snyder 1999).	
Quantification of exposure levels to population(s) at increased risk	No formal quantification	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed	N/A	
Risk Characterization		
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	Adverse effect on structure and function of system *Microstegium* apparently reduces the diversity of the herbaceous community and may threaten populations of endangered plants. The dense growth of "lawns" of *Microstegium* is significantly different in character from the low, open herbaceous communities that are replaced. The impact of this change is unknown, but quite possibly dramatic. The changes in soil profile and chemistry associated with *Microstegium* invasion are quite dramatic and may seriously impact functioning. These changes may have a very long recovery time.	3

Issue: Japanese Stilt Grass
Author: Tim Casey
Version: 03/27/00

Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Often and increasing Populations of *Microstegium* have been increasing in the state at exponential rates (D. Snyder, pers. comm.). Without viable large-scale control strategies, established populations are likely to persist.	5
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	5-10% of the State impacted Almost all of the suitable riverine habitat is invaded or at high risk of invasion. Several mesic forests are also at high risk.	2
	Total	30
Assessment of uncertainties in this assessment (H,M,L) and brief description	M: The spread of this invasive species and some of its ecological effects (e.g. the effects on soil) are documented, but most of the observations are anecdotal or correlational at best.	
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description. (Data Gaps; highlight significant data needs)	M: Current research in the Ehrenfeld lab at Rutgers University is exploring the connection between *Microstegium* and the soil, but many of the basic questions about other impacts remains. The expansion of this species has been perceived (Hunt and Zaremba 1992), but given the broad habitat tolerance of the species, the impacts could be far greater than currently expected.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, , =, where + is improvement), and brief description.	+: Control methods have been studied in other states (Woods and Ashburn 1989), but none are applicable on a broad scale. Herbicides can be effective against standing crop, but the ensuing disturbance (which would destroy non-target species as well) would stimulate recruitment from the seed bank. Weeding or mowing population after flowering but before seed set may be effective, but must continue until this seed bank is exhausted to be successful. Small population can be difficult to detect. In some parts of the range, *Microstegium* is affected by a fungal disease and research on this fungus as a possible control agent is ongoing (Barden 1991). -: Risks to threatened and endangered species may be acute, but are unstudied.	
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	L: Potential for drastic negative short-term impacts are low. However, as with any plant that can overgrow an entire community, *Microstegium* runs the risk of extirpating populations of rare and endangered species. No current data supports this risk, but the problem is unstudied.	

Issue: Japanese Stilt Grass
Author: Tim Casey
Version: 03/27/00

Link to other Work Groups (e.g., socioeconomic impacts)	Socioeconomic impacts: Recreational/Cultural: The formation of dense lawns of *Microstegium* along rivers and streams changes the character of many of the State's waterways.
Extent to which threat is currently regulated	Minimal (if existent at all). ONLM is currently engaged in experimentation and evaluation of control techniques. USDA NRCS also sponsors projects to control exotic species.
Barriers to restoration	Minimal understanding of the dispersal vectors. Control strategies are non-specific and costly, and largely ineffective.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	L: unmanaged habitat may act as sources.
Small business industry	M: landscapers, plant nurseries and plant wholesalers that transport container grown plants or other soil.
Transportation	M: roads and canals are natural dispersal vectors; transport of fill may facilitate dispersal.
Residential	L
Agriculture	L: unmanaged habitat may act as sources.
Recreation	L
Resource extraction	L
Government	L: unmanaged open space allows threat to become widespread.
Natural sources/processes	M: invaded natural areas act a sources.
Orphan contaminated sites	M: unmanaged habitat may act as sources
Diffuse Sources	
Sediment sinks	L
Soil sinks	H: *Microstegium* produces a seed bank that confounds population control
Non-local air sources incl. deposition	L
Biota sinks	L

Issue: Japanese Stilt Grass
Author: Tim Casey
Version: 03/27/00

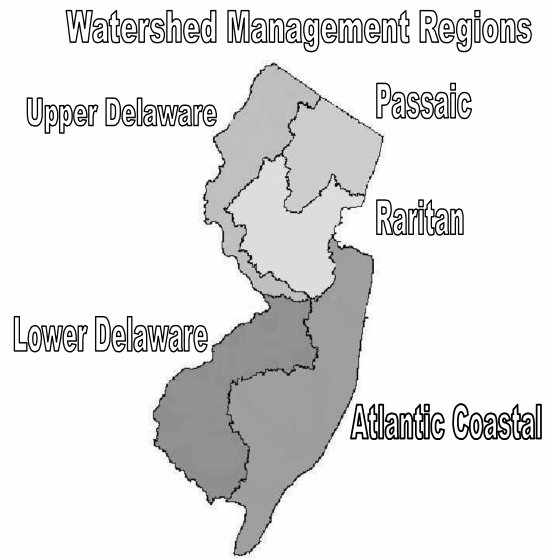
Statewide Analysis of Threat
Threat = Invasive-Japanese Stilt Grass

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	N/A	N/A	N/A	N/A
Wetlands	3	4	3	36
Forests	3	3	3	27
Grasslands	4	3	3	36
			Total Score	99
			Average Score	19.8

Risk by Watershed Management Region

THREAT = Japanese Stilt Grass	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	N/A	M	M	M
Passaic	N/A	N/A	M	M	M
Raritan	N/A	N/A	M	M	M
Atlantic	N/A	N/A	M	L	L
Lower Delaware	N/A	N/A	M	L	L
Region/Watershed (secondary)					
Urban	N/A	N/A	M	L	M
Suburban	N/A	N/A	H	M	M
Rural	N/A	N/A	H	M	M

H=high, M=medium, L=low;



References:

Barden, L.S. 1987. Invasion of *Microstegium vimineum* (Poaceae), an exotic, annual, shade-tolerant, C4 grass, into a North Carolina floodplain. Amer. Midland Naturalist 118:40-45.

Barden, L.S. 1991. Element Stewardship Abstract for *Microstegium vimineum*. The Nature Conservancy, Arlington, VA.

Ehrenfeld, J.G. 1999. A rhizomatous, perennial form of *Microstegium vimineum* (Trin.) A. Camus in New Jersey. Journal of the Torrey Botanical Society 126:352-358.

Fairbrothers, D.E. and J.R. Gray. 1972. *Microstegium vimineum* (Trin.) A. Camus (Gramineae) in the United States. Bull. Torrey Bot. Club. 99:97-100.

Hough, M. 1983. New Jersey Wild Plants, Harmony Press, Harmony NJ.

Hunt, D.M. and R.E. Zaremba. 1992. The northeastward spread of *Microstegium vimineum* (Poaceae) into New York and adjacent states. Rhodora 94:167-170.

Kaufman, S. and D. Snyder. 1999. Nonindigenous Invasive Plant Species in New Jersey. Draft report submitted to NJDEP Division of Science, Research, and Technology.

Kourtev, P.S., J.G. Ehrenfeld, and W.Z. Huang. 1998. Effects of Exotic Plant Species on Soil Properties in Hardwood Forests of New Jersey. Water, Air, and Soil Pollution 105:493-501.

Redman, D. 1995. Distribution and Habitat Types for Nepal Microstegium [*Microstegium vimineum* (Trin.) Camus] in Maryland and the District of Columbia. Castanea 60: 270-275.

Swearingen, J. 1999. Japanese Stilt Grass. NPCI Exotic Plant Working Group Fact Sheet. Available online: http://www.nature.nps.gov/npci/epwg/mivi1.htm

Tennessee Exotic Pest Council. 2000. TN-EPPC Manual: Japanese Grass or Eulalia. Available on-line: http://www.webriver.com/tn-eppc/manual/micros.htm

Winter, K., M.R. Schmitt, and G.E. Edwards. 198. *Microstegium vimineum*, a shade adapted C4 grass. Plant Sci. Letters 24:311-318.

Woods, F.W. and E.L. Ashburn. 1989. Control of *Paulownia tomentosa* and *Microstegium vimineum* in National Parks. Report to Great Smoky Mountains National Park.

Issue: Multiflora Rose *(Rosa multiflora)*
Author: Christopher Martine
Version: 03/27/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Multiflora Rose** *Rosa multiflora*
Description of stressor	*Rosa multiflora*, known commonly as multiflora rose or rambler rose, is a semi-evergreen shrub of the Rosaceae family. It is native to Japan, Korea and Eastern China. The species was first introduced to North America around 1886 (Dirr, Rehder) as a hardy rootstock for ornamental roses. In later years, a number of state and federal agencies championed its use for wildlife cover and erosion control, distributing seedlings throughout the East and Midwest. *Rosa multiflora* now inhabits over 45 million acres of pasture, parks, recreation areas, rights-of-way, and other non-tilled lands in the US alone (Epstein and Hill). The species is a common invasive in New Jersey in riparian areas, thickets, open woodlands, old fields, and on forest edges. *Rosa multiflora* is less common in the Pine Barrens (Hough) and does not grow in standing water or on excessively dry soils. *Rosa multiflora* overwhelms and replaces other plant species, often forming impenetrable thickets. The shrub is considered a noxious weed in much of the US and is present throughout the country with the exception the Rocky Mountains, the Southeastern Coastal Plain, and the Nevada and California desert areas (Eckardt).
Stressor-specific impacts considered: Biological integrity Biodiversity Ecosystem function	Biological integrity: The species adversely affects abundances of native plant species. Additionally, the late ripening of the fruit has affected bird population dynamics as it has allowed certain frugivorous birds to expand their winter range (Stiles). Biodiversity: Once established, *Rosa multiflora* outcompetes existing vegetation, often forming pure semi-clonal stands through the layering of cane tips or by budding from wounded roots stocks (Epstein and Hill). Presence of the species may increase the diversity of birds and small mammals by providing cover, nesting sites, and food in the form of rose hips. High rodent densities and shade are functions of the formation of *Rosa multiflora* thickets and each may prevent germination and growth of other plant species under cover of the shrub. Ecosystem Function: The species replaces native vegetation and native cover, thus reducing habitat diversity. Inability of other woody plants to become established may lead to successional “dead ends.” Larger animals are unable to pass through dense stands and predators are unable to obtain prey hidden within thickets. Overall productivity of the ecosystem and wildlife populations are probably increased.
Key impacts selected (critical ecological effects)	Loss of native species. Reduction in plant species diversity. Habitat degradation.
Exposure Assessment	

Issue: Multiflora Rose *(Rosa multiflora)*
Author: Christopher Martine
Version: 03/27/00

Exposure routes and pathways considered	First introduced in the late 1800's as ornamental rootstock. Further introduced by conservation efforts taking place from the 1930's to the 1970's. Invasions now facilitated by existing populations of naturalized plants. No longer available in the nursery trade. Mechanisms for invasion: Species produces prolific, late-ripening fruit crops. Fruits are available throughout the winter months and uneaten fruits remain on the plant into spring. Initial colonization is mostly through bird dispersal of seed, but invasion is further facilitated and driven by vigorous clonal spread through layering. Seeds remain viable for years after initial dispersal. Invasions are less common in very wet or very dry soils.	
Population(s)/ecosystem(s) exposed statewide	Forest edge habitats, forest clearings (e.g. blowdowns, insect infestations), disturbed sites, abandoned fields, roadsides, riparian corridors, thickets, woodlands. The plant's semi-evergreen habit allows it to become established in forested habitats.	
Quantification of exposure levels statewide	No real data exists, but considered locally prevalent throughout the state with the exception of the central Pine Barrens (Hough). Moisture: A poor pioneer in standing water and on very dry soils. Once established, is very drought tolerant and may become invasive on dry sites. Biological factors: Susceptible to rose rosette disease, a native disease spread by the eriophyid mite (Epstein and Hill, Eckardt). Also affected by the European rose chalicid, an introduced phytophagous wasp.	
Specific population(s) at increased risk	All native pioneer/edge/understory species of trees, shrubs, and herbs. Potential risks to birds affected by increased populations of wintering frugivores. Thickets may exclude or prevent the movement of larger mammals.	
Quantification of exposure levels to population(s) at increased risk	None.	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed	None.	
Risk Characterization		
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score

Issue: Multiflora Rose *(Rosa multiflora)*
Author: Christopher Martine
Version: 03/27/00

Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure		3
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)		5
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted		2
	Established invasions are generally irreversible without manual removal or herbicide application. Bio-controls may be effective. Invasions are frequent and increasing as forest	Total: 30

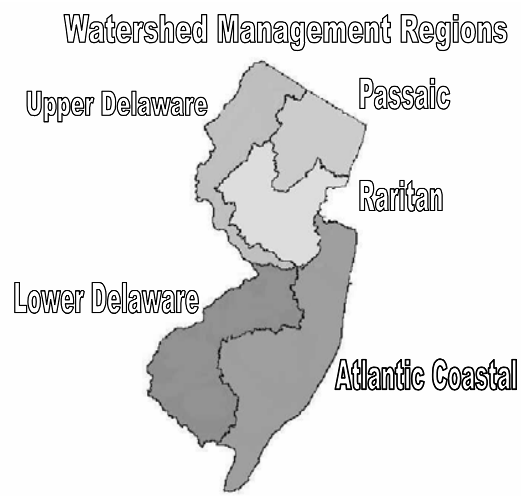
	fragmentation continues and agricultural lands are abandoned.	
Assessment of uncertainties in this assessment (H,M,L) and brief description	M: Very little actual data exists.	
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description. (Data Gaps; highlight significant data needs)	M: Studies should document the actual current population of *Rosa multiflora* in New Jersey. Additionally, the impact on native species should be quantified, both in terms of the plant species displaced and changes in wildlife population dynamics.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description	(--)The species is difficult and costly to eradicate once established. Trends in land use and landscape management point towards an increase in potential *Rosa multiflora* habitat.	
Potential for catastrophic impacts (H,M,L) and brief description	Low	
Link to other Work Groups (e.g., socioeconomic impacts)	Potential economic impacts on agriculture and the forest products / timber industry. *Rosa multiflora* can render land unusable.	
Extent to which threat is currently regulated or otherwise managed	Not regulated. Occasional local eradication projects undertaken.	
Barriers to restoration	Once established, *Rosa multiflora* quickly becomes a problem. Eradication is labor-intensive, time-consuming, and potentially costly. Herbicides and bio-controls may affect non-target species. Progeny source is well-established and prevalent. Dispersal agents are prevalent and very effective.	
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources		
NJ Primary Sources		
Large business/industry	L: Unmanaged lands.	
Small business industry	L: Unmanaged lands.	
Transportation	M: Roadsides, embankments, railroadsides.	
Residential	M: Propagation of species as wildlife cover/food.	
Agriculture	H: Old “living fences” and wildlife plantings, unmanaged field boundaries, old fields.	
Recreation	H: Unmanaged lands/parks, edges of rec. fields.	
Resource extraction	M: Logged and mined lands.	
Government	H: Open space purchases coupled with lack of active management, particularly former farmland.	
Natural sources/processes	H: Extant populations.	

Orphan contaminated sites	NA
Diffuse Sources	NA
Sediment sinks	NA
Soil sinks	H: Seed bank.
Non-local air sources incl. deposition	NA
Biota sinks	NA

Issue: Multiflora Rose *(Rosa multiflora)*
Author: Christopher Martine
Version: 03/27/00

Statewide Analysis of Threat
Threat = Invasive – Multifloral Rose

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	N/A	N/A	N/A	N/A
Wetlands	3	4	3	36
Forests	3	5	3	45
Grasslands	3	4	2	24



Total Score	105
Average Score (Total ÷ 5)	21

Risk by Watershed Management Region

THREAT = Multifloral Rose	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	N/A	M-H	H	M

Passaic	N/A	N/A	M-H	H	M
Raritan	N/A	N/A	M-H	H	M
Atlantic	N/A	N/A	M	H	M-L
Lower Delaware	N/A	N/A	M	H	M-L
Region/Watershed (secondary)					
Urban	N/A	N/A	M-H	H	M
Suburban	N/A	N/A	M-H	H	M
Rural	N/A	N/A	M-H	H	M

H=high, M=medium, L=low;

References for *Rosa multiflora*

Clemants S. 1996. Metropolitan Plants: *Rosa multiflora*. Brooklyn Botanic Garden. www.bbg.org

Dirr MA. 1998. Manual of Woody Landscape Plants. Stipes Publishing.

Eckardt N. 1987. Element stewardship act for *Rosa multiflora* – rambler rose. The Nature Conservancy.

Epstein AH, Hill. 1999. Status of rose rosette disease as biological control for multiflora rose. Plant Disease. 83(2): 92-101.

Hough MY. 1983. New Jersey Wild Plants. Harmony Press.

McDonnell MJ. 1986. Old field vegetation height and dispersal pattern of bird-disseminated woody plants. Bull. Torrey. 113:6-11.

Myster RW, Pickett STA. 1990. Initial conditions, history, and successional pathways in ten contrasting old fields. Amer. Midland Naturalist. 124:231-238.

Rehder A. 1990. Manual of Cultivated Trees and Shrubs. Dioscorides Press.

Robertson DJ, Robertson MC, Tague T. 1994. Colonization dynamics for four exotic plants in a northern Piedmont natural area. Bull. Torrey. 121: 107-118.

Stiles EW. 1982. Range expansion of mockingbird and multiflora rose in the northeast United States and Canada. American Birds. 36:358-364.

Virginia Natural Heritage Program. Invasive alien plants: multiflora rose (*Rosa multiflora* Thunberg).

Issue: Norway Maple *(Acer Platanoides)*
Author: Christopher Martine
Version: 03/27/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Norway Maple** *Acer platanoides*
Description of stressor	*Acer platanoides*, known commonly as Norway maple, is a deciduous tree of the Aceraceae family. It is the most widespread maple in Europe, occurring over much of the continent in well-drained forests (Nowak and Rowntree 1990). The species was first introduced to North America at Philadelphia around 1756 (Nowak and Rowntree 1990, Dirr 1998). The tree has been widely planted as a street tree since that time and has naturalized throughout the Metropolitan area. It is currently considered an invasive species in New Jersey (NJDEP 2000). *Acer platanoides* is a common species in fragmented forests, open woodlands, successional forests, urban woodlots, vacant lots, and forest edges throughout much of the state. The tree is shade tolerant in all life stages (Webb and Kaunzinger, 1993), tolerant of environmental stresses, and produces large widely dispersed seed crops. It outcompetes and replaces other trees, shrubs, and herbs throughout much of its naturalized range. Continued fragmentation / degradation of forest habitats, frequent use of the species as a street tree, and the current prevalence of the species in many woodlands will most likely further increase the occurrence of *Acer platanoides* in New Jersey.
Stressor-specific impacts considered: Biological integrity Biodiversity Ecosystem function	**Biological integrity:** The species adversely affects abundances of native species by shading-out and outcompeting understory wildflowers and woody seedlings. **Biodiversity:** Species richness declines under the dense shade of Norway maple canopies (Wyckoff and Webb, 1996). **Ecosystem Function:** The species replaces native vegetation and native cover, thus reducing habitat diversity and reducing the prevalence of important wildlife food resources.
Key impacts selected (critical ecological effects)	Loss of native species. Reduction in species diversity. Decreased wildlife resources. Loss of habitat.
Exposure Assessment	
Exposure routes and pathways considered	First introduced as an ornamental species in the mid-to-late 1700's. Invasions now facilitated by existing populations of naturalized/escaped plants and by local plantings. Its proclivity for invading undisturbed habitats makes Norway maple an exception amongst invasive plants. Still one of the most commonly planted street trees in NJ. **Mechanisms for invasion:** Species produces prolific wind-borne seed crops (samaras). Seeds contain survival resources for germination in shade. Dense shade produced by mature trees lends itself to successful reproduction and

	growth of seedlings.	
Population(s)/ecosystem(s) exposed statewide	Forest edge habitats, vacant lots, forest clearings (e.g. blowdowns, insect infestations, harvests), fragmented forests, open woods, successional forests (including abandoned farmland), and urban woodlands. Species outcompetes most native and exotic shade-tolerant species.	
Quantification of exposure levels statewide	Little real data exists, but considered very prevalent throughout the northern and central parts of the state (Clemants 1990, Hough 1989) and in urbanized areas of the south. Less common or absent as an escape in the Pine Barrens and on the southern coastal plain. **Pollution:** Norway maple is considered tolerant of most pollutants, but urban plantings have been seriously affected by a combination of environmental and disease problems collectively referred to as "maple decline." **Moisture:** Able to withstand droughty conditions and may become invasive in dry woodlands. Less successful in very moist soils. **Biological factors:** Susceptible to a number of diseases, some of which contribute to "maple decline" in urban plantings.	
Specific population(s) at increased risk	Native species of trees, shrubs, and herbs occurring in well-drained, fertile woodlands throughout New Jersey. Directly outcompetes native sugar maple (*Acer saccharum*) in early life stages. Risks to frugivores / granivores / herbivores associated with replaced species have not been quantified, but may be substantial.	
Quantification of exposure levels to population(s) at increased risk	None.	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed	None.	
Risk Characterization		
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude) Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery	Norway Maple replaces native vegetation and native cover, thus reducing habitat diversity and reducing the prevalence of important wildlife food resources	Score 3

3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure		3
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)		5
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	Occurs throughout New Jersey	2
	Able to establish itself in intact woodlands and replace or diminish native plant communities. Particularly common in north and central New Jersey. In most cases, established invasions are irreversible without manual removal. Invasions are common and increasing as habitat fragmentation and street tree plantings each continue to occur.	Total: 30
Assessment of uncertainties in this assessment (H,M,L) and brief description	M: Very little actual data exists.	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	M: Studies need to document the actual current population of *Acer platanoides* in New Jersey. Additionally, the impact of native species replacement should be quantified, both in terms of the plant species displaced and affected wildlife. Allelopathy and anti-herbivore defenses have been theorized, but not quantified. Further identification of Norway maple's effect on understory growth and reproduction is needed.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is	–: The species' large bank of seedlings and saplings in many woodlands points towards a future increase in Norway maple populations (Wyckoff and Webb, 1996). It's shade-tolerance and highly-effective mode of seed dispersal	

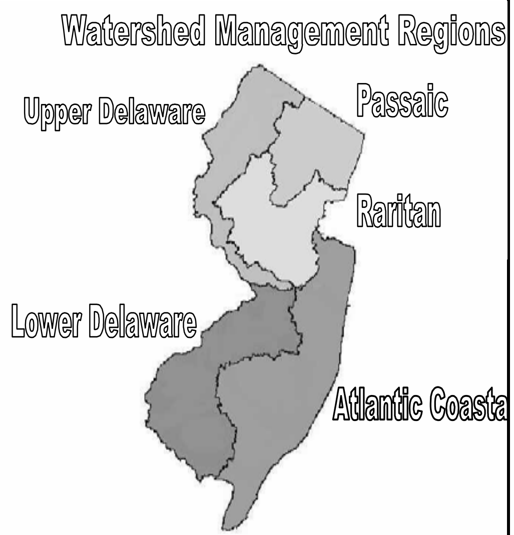
this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description.	maple populations (Wyckoff and Webb, 1996). It's shade-tolerance and highly-effective mode of seed dispersal create a feedback loop that promotes continual invasion and spread of the species once it is established. Norway maple is still one of the most commonly planted street trees in the state.
Potential for catastrophic impacts (H,M,L) and brief description	Low
Link to other Work Groups (e.g., socioeconomic impacts)	Potential economic impacts on the forest products / timber industry. Directly outcompetes and replaces sugar maple (*Acer saccharum*).
Extent to which threat is currently regulated or otherwise managed	Not regulated. Occasional local eradication projects undertaken.
Barriers to restoration	Seeds are produced prolifically, are widely dispersed, and show high rates of germination (Young and Young, 1992). Once established, Norway maple can be a rapid invader, quickly overtaking the forest understory. Mature trees facilitate growth of subsequent generations. Eradication is labor-intensive, time-consuming, and potentially costly. Progeny source is well established, prevalent, and continually introduced.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	L: Unmanaged lands, landscape plantings.
Small business industry	M: Unmanaged lands, landscape plantings.
Transportation	M: Roadsides, embankments, other edge habitats.
Residential	H: Propagation of species as ornamental.
Agriculture	M: Old shelter belts, unmanaged field boundaries, regrowth forests on old croplands.
Recreation	L: Unmanaged lands, edges of rec. fields.
Resource extraction	M: Timber harvests.
Government	M: Open space purchases coupled with lack of management, unmanaged parklands.
Natural sources/processes	H: Extant populations.
Orphan contaminated sites	N/A
Diffuse Sources	
Sediment sinks	N/A
Soil sinks	M: Seed bank.
Non-local air sources incl. deposition	N/A

Biota sinks	N/A

Issue: Norway Maple *(Acer Platanoides)*
Author: Christopher Martine
Version: 03/27/00

Statewide Analysis of Threat — Threat = Norway Maple

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	NA	NA	NA	NA
Marine Waters	NA	NA	NA	NA
Wetlands	3	4	3	36
Forests	3	5	4	60
Grasslands	3	4	2	24



Total Score	120
Average Score (Total ÷ 5)	24

Risk by Watershed Management Region

Norway Maple	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	NA	NA	M-H	H	M
Passaic	NA	NA	M-H	H	M
Raritan	NA	NA	M-H	H	M
Atlantic	NA	NA	M	H	M

Lower Delaware	NA	NA	M	H	M
Region/Watershed (secondary)					
Urban	NA	NA	M-H	H	M
Suburban	NA	NA	M-H	H	M
Rural	NA	NA	M-H	H	M

H=high, M=medium, L=low, NA = not applicable

References:

Clemants S., Ed. 1999. New York Metropolitan Flora: Woody Plant Workbook. Brooklyn Botanic Garden.

Dirr M.A. 1978. Tolerance of seven woody ornamentals to soil-applied sodium chloride. J. Arboriculture 4:7 162-165.

Dirr M.A. 1998. Manual of Woody Landscape Plants. Stipes Publishing.

Gill D.S., Marks P.L. 1991. Tree and shrub seedling colonization of old fields in central New York. Ecol. Monog. 61: 183-205.

Gleason H.A., Cronquist A. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. New York Botanical Garden.

Hough M.Y. 1983. New Jersey Wild Plants. Harmony Press.

Martine C.T. 2000. Trees of New Jersey and the Mid-Atlantic States. NJDEP (Forest Service).

NJDEP. 2000. Invasive Species Division Order Number 34 (draft).

Nowak D.J., Rowntree R.A. 1990. History and range of Norway maple. J. Arboriculture 16:11 291-296.

Sinclair W.A., Lyon H.H., Johnson W.T. 1987. Diseases of Trees and Shrubs. Cornell University Press.

Webb S.L., Kaunzinger C.K. 1993. Biological invasion of the Drew University (New Jersey) forest preserve by Norway maple (*Acer platanoides* L.). Bull. Torrey 120:3 343-349.

Wyckoff P.H., Webb S.L. 1996. Understory influence of the invasive Norway maple (*Acer platanoides*). Bull. Torrey 123:3 197-205.

Young J.A., Young C.G. 1992. Seeds of Woody Plants in North America. Dioscorides Press.

Issue: Purple Loosestrife *(Lythrum salicaria)*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Purple Loosestrife** *Lythrum salicaria*
Description of stressor	Lythrum is a stout, erect perennial herb with a strongly developed taproot and an average height of 1-3 m. Mature plants can have 30 to 50 shoots that form wide-topped crowns and dominate the herbaceous canopy of heavily infested wetlands. It has a four angled stem with opposite or whorled lanceolate leaves. The inflorescence is a 1-4 dm spike of magenta (occasionally white or pink) flowers with 5-7 petals and varied shape (heterostyly). The plant flowers from June to September. The fruit is a capsule that contains many small (0.6 mg) black seeds. (Bender 1987, Tennessee 2000, Virginia 2000)
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Biological integrity: Dense growth in wetlands reduces the value of wetlands as wildlife habitat and alters normal community structure (Swearingen 1999, Virginia 2000) Biodiversity: Lythrum is a direct threat to several state and federally listed species. The primary threat is the closure of the canopy in open wetlands, altering the habitat of several endangered plants and animals (D. Snyder, pers. comm.). Habitat/ecosystem health: Lythrum often invades cattail and sedge meadows, altering conditions such that native plants and wildlife are displaced (Virginia 2000). Ecosystem function: Canopy closure by Lythrum affects light and temperature regimes, presumably affecting nutrient cycling and microbial communities (M. Palmer, unpublished data). High productivity by Lythrum may also affect litter dynamics.
Key impacts selected (critical ecological effects)	Degradation of wetland plant and animal communities Threat to threatened and endangered plants and wildlife
Exposure Assessment Exposure routes and pathways considered	 Lythrum is dispersed by wind, water, and animal vectors. The seeds are very small and light and are easily carried by both wind and water. Some birds have been observed to consume the seeds and seeds often travel in mud attached to animals and people (Bender 1987).

	Lythrum was first introduced to North America in the early 1800s for use as a medicinal and garden plant, and may also have been a contaminant of ship ballast. In the early part of the 19th century, the distribution was limited to coastal habitat. The range expanded inland beginning in the 1880s as construction of inland waterways and roads increased. The range expanded further with the commercial distribution of the plant for horticulture and with the propagation of seed for bee forage (Tennessee 2000). In New Jersey, Lythrum was first collected in 1865 in Camden Co. (Kaufman and Snyder 1999) Lythrum is a fast growing and fecund plant. A mature plant can produce 2.5 million seeds annually (Swearingen 1999, Tennessee 2000). Seedling density in infested areas can reach 10,000-20,000 plants per square meter and seedlings can grow at rates greater than 1 cm per day (Tennessee 2000). Lythrum can swamp out the seed and seedling bank of most of our open-canopied wetlands (M. Palmer, unpublished data). Lythrum responds particularly well to disturbance, often forming dense colonies within a few years of establishment on disturbed wetland substrate (Virginia 2000).
Population(s)/ecosystem(s) exposed statewide	Lythrum is present in all counties of New Jersey (Hough 1983, D. Snyder, pers. comm.), but the greatest risk is in the glaciated regions in the northern part of the state and on the inner coastal plain. The largest populations are in the Passaic, Hackensack, Great Swamp, and Delaware drainages (D. Snyder, pers. comm.). Almost all of the limestone fens of northern New Jersey are seriously impacted.
Quantification of exposure levels statewide	No formal quantification (although the National Park Service has been monitoring the spread of Lythrum in the Delaware Water Gap)(T. Breden, pers. comm.)
Specific population(s) at increased risk	all open wetland habitats, particularly cattails marshes, sedge meadows and fens
Quantification of exposure levels to population(s) at increased risk	No formal quantification though is has been observed that almost all (if not all) of the limestone fens of northern New Jersey are infested (D. Snyder, pers. comm.)
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	N/A
Risk Characterization	

Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score

Issue: Purple Loosestrife *(Lythrum salicaria)*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	Serious damage: Infested wetlands run very high risk of losing several threatened and endangered species and may drive other species into this category. The plant community is fundamentally changed from a open-canopy diverse herbaceous and/or graminoid community to a dense, closed canopy Lythrum stand. These changes in the plant community effect changes in wildlife habitat (D. Snyder, pers. comm.). Once Lythrum populations are established they are difficult to control. Manual removal is difficult and rarely entirely successful (root fragments can resprout and seed banks are typically dominated by Lythrum) and chemical control is risky in aquatic habitats (Virginia 2000, Bender 1987).	4
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Often and continuing Lythrum is likely to continue to expand into non-infested habitat. Established populations are expected to persist.	4
Size of population(s) and/or extent of the State/habitat affected (magnitude)	5-10% of the State impacted Almost all of the freshwater wetlands in the state are at risk of Lythrum invasion.	2
	Total	32
Assessment of uncertainties in this assessment (H,M,L) and brief description	M: Very little quantitative data exists for Lythrum invasion, though dramatic impacts are clear in several cases.	
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description. (Data Gaps; highlight significant data needs)	M: Vegetation data documenting a decline in species diversity and the elimination of rare plants are only qualitative. M: Ecosystem level effects are largely based on anecdotal evidence. Given the drastic changes to light, temperature, and litter dynamics following Lythrum invasion, the impacts are severe, but require documentation.	

Issue: Purple Loosestrife *(Lythrum salicaria)*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description.	+: The state Division of Fish and Game and the NJ Dept. of Agriculture Beneficial Insects Laboratory are both working to introduce biological control insects into infested wetlands. Early data from other states suggest that biocontrol may limit Lythrum population size and density (B. Blossey, pers. comm.) -: Risks to threatened and endangered species may be quite acute, but have not yet been adequately documented (D. Snyder, pers. comm.).
Potential for catastrophic impacts (H,M,L) and brief description	M: Lythrum has the real potential to extirpate several rare and endangered plant species.
Link to other Work Groups (e.g., socioeconomic impacts)	Socioeconomic impacts: Agricultural: Lythrum grows in drainage channels, causing damage to fields and crops (F. Yoder, pers. comm.) Wetland recreation: Lythrum decreases the quality of habitat for waterfowl (Bender 1987). Cultural resources: Lythrum can colonize river and canal banks, impacting important historic and natural sites (i.e. D + R canal) Wetland restoration: Lythrum threatens the diversity and integrity of wetland restoration projects (i.e. Duck Island) (M. Leck, pers. comm.)
Extent to which threat is currently regulated or otherwise managed	Minimal, with the exception of some biocontrol programs on state gamelands. Small, isolated wetlands are completely unregulated.
Barriers to restoration	Public support of this "attractive wildflower", continued use in gardens and landscaping
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	L: unmanaged wetlands may act as sources
Small business industry	H: landscapers, plant nurseries and plant wholesalers who propagate and sell Lythrum
Transportation	M: roads and canals are natural dispersal vectors; Lythrum has been used in "roadside beautification projects" on the Atlantic City Expressway
Residential	M: home gardeners
Agriculture	L: unmanaged wetlands may act as sources
Recreation	L
Resource extraction	L
Government	L
Natural sources/processes	M: infested natural areas act a sources
Orphan contaminated sites	M: unmanaged wetlands may act as sources

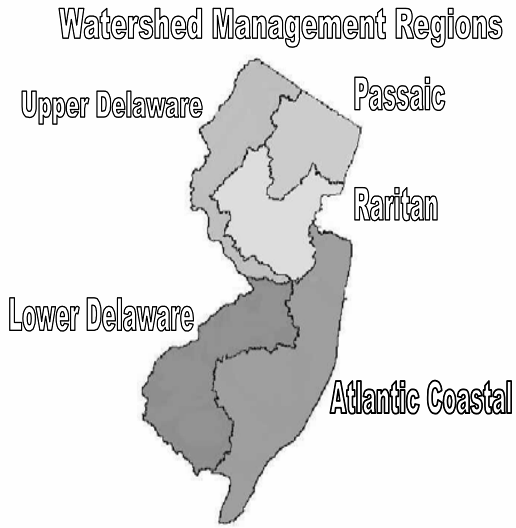
Issue: Purple Loosestrife *(Lythrum salicaria)*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

Diffuse Sources	
Sediment sinks	L
Soil sinks	H: Lythrum produces vast amounts of seed that dominate seed and seedling banks in infested wetlands. (M. Palmer, unpublished data)
Non-local air sources incl. deposition	L
Biota sinks	L

Issue: Purple Loosestrife *(Lythrum salicaria)*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

Statewide Analysis of Threat Threat = Invasive – Purple Loosestrife

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	N/A	N/A	N/A	N/A
Wetlands	4	5	4	80
Forests	4	2	2	16
Grasslands	4	2	2-3	16-24



Total Score	112-120
Average Score (Total ÷ 8)	22.4-24

Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	N/A	H	L-M	L-M
Passaic	N/A	N/A	H	L-M	L-M
Raritan	N/A	N/A	H	L-M	L-M
Atlantic	N/A	N/A	H	L-M	L-M

Lower Delaware	N/A	N/A	H	L-M	L-M
Region/Watershed (secondary)					
Urban	N/A	N/A	H	L	L-M
Suburban	N/A	N/A	H	M	L-M
Rural	N/A	N/A	H	M	L-M

H=high, M=medium, L=low, NA = not applicable

References:

Bender, J. 1987. Element Stewardship Abstract for Lythrum salicaria. The Nature Conservancy, Arlington, VA.

Hough, M. 1983. New Jersey Wild Plants, Harmony Press, Harmony NJ.

Kaufman, S. and D. Snyder. 1999. Nonindigenous Invasive Plant Species in New Jersey. Draft report submitted to NJDEP Division of Science, Research, and Technology

Swearingen, J. 1999. Purple Loosestrife. NPCI Exotic Plant Working Group Fact Sheet. Available online: http://www.nature.nps.gov/npci/epwg/lysa1.htm

Tennessee Exotic Pest Council. 2000. TN-EPPC Manual: Purple Loosestrife. Available on-line: http://www.webriver.com/tn-eppc/manual/lythru.htm

Virginia Natural Heritage Program. 1998. Fact Sheet – Purple Loosestrife. Available on-line:
http://www.state.va.us/~dcr/dnh/invlyth.htm

Issue: Tree-of-Heaven: *Ailanthus altissima*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Tree-of-Heaven** *Ailanthus altissima*
Description of stressor	*Ailanthus altissima*, known commonly as tree-of-heaven, is a deciduous tree of the Simaroubaceae family. It is native to China. The species was first introduced to North America at Philadelphia in 1784. From this planting and another on Long Island in 1790, the tree has spread and naturalized throughout the Metropolitan area. *Ailanthus* is a common invasive in New Jersey on forest edges, roadsides, embankments, abandoned lots, old fields, and other disturbed habitats. The tree is shade intolerant and most common on soils where moisture is not limiting (Feret, 1985). It is also a poor competitor on very wet sites. *Ailanthus* outcompetes and replaces other pioneer trees, shrubs, and herbs throughout much of its naturalized range. The tree is considered an invasive weed in most parts of temperate North America and much of Europe (Feret). Continued fragmentation and degradation of forest habitats will most likely increase the occurrence of *Ailanthus* in New Jersey.
Stressor-specific impacts considered: Biological integrity Biodiversity Ecosystem function	Biological integrity: The species adversely affects abundances of native pioneer species, some of which are considered important wildlife food sources (e.g. *Prunus serotina* (Black Cherry), *Juglans nigra* (Black Walnut), *Vitis* spp.). Allelopathy inhibits growth and reproduction of associated plant species, influencing spatial distribution and possibly contributing to genetic change within neighboring plants (Lawrence). Biodiversity: The species outcompetes most other native and exotic pioneers, often forming pure clonal stands once established. Ecosystem Function: The species replaces native vegetation and native cover, thus reducing habitat diversity. The species has no value as a wildlife food source. Allelopathic compounds toxify neighboring plants and leaf foragers (Lawrence, 1991).
Key impacts selected (critical ecological effects)	Loss of native species. Reduction in species diversity. Decreased wildlife resources. Loss of habitat.
Exposure Assessment	
Exposure routes and pathways considered	First introduced in the late 1800's (primarily as an ornamental species). Invasions now facilitated by existing populations of naturalized plants. Mechanisms for invasion: Species produces prolific wind-borne seed crops. Initial colonization is by seed dispersal on disturbed soils, but invasion is further facilitated and driven by vigorous clonal growth in the form of root sprouts. Invasions are less common in very wet or very dry soils.

Issue: Tree-of-Heaven: *Ailanthus altissima*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

Population(s)/ecosystem(s) exposed statewide	Forest edge habitats, forest clearings (e.g. blowdowns, insect infestations), disturbed sites, urban lots, abandoned fields, roadsides. Species outcompetes most native and exotic pioneer species.	
Quantification of exposure levels statewide	No real data exists, but considered very prevalent throughout the northern and central parts of the state and in urbanized areas of the south. Less commonly invasive on the coastal plain. Pollution: *Ailanthus* is considered highly tolerant of most pollutants, but has been found to be susceptible to ozone (Davis and Coppolino, 1974). Moisture: A poor pioneer competitor on very wet and very dry soils. Once established, is very drought tolerant and may become invasive on dry sites. Biological factors: Susceptible to a number of pests and diseases, although none are considered serious. Seed germination and ramet growth are inhibited by the presence of plant litter and subsequent increase in macroinvertebrate populations (Facelli, 1994).	
Specific population(s) at increased risk	All native pioneer species of trees, shrubs, and herbs. Native woody plant species directly at risk include: *Prunus serotina, Juglans nigra, Populus* spp., *Acer negundo, Vitis* spp., *Liriodendron tulipifera, Fraxinus americana, Rhus* spp., *Sassafras albidum, Morus rubra, Rubus* spp., and *Ulmus* spp. Risk to frugivores and/or granivores associated with the above have not been quantified, but may be substantial.	
Quantification of exposure levels to population(s) at increased risk	None.	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed	None.	
Risk Characterization		
Risk estimate(s) by population at risk		Score

Issue: Tree-of-Heaven: *Ailanthus altissima*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	Adversely affects structure and function of the community by outcompeting native species. As a result, Biodiversity is reduced and ecosystem function is impaired.	3
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Invasion occurs often and appears to be increasing. Prevalence of disturbed habitat throughout New Jersey facilitates its expansion.	5
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted		2
	Limited to edge or disturbed habitats, but prevalent in most of these situations. Particularly common in north and central New Jersey. In most cases, established invasions are irreversible without manual removal. Invasions are frequent and increasing as habitat fragmentation and habitat disturbance continues.	Total: 30

Issue: Tree-of-Heaven: *Ailanthus altissima*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

Assessment of uncertainties in this assessment (H,M,L) and brief description	M: Very little actual data exists.
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description. (Data Gaps; highlight significant data needs)	M. Studies need to document the actual current population of *Ailanthus altissima* in New Jersey. Additionally, the impact of native species replacement should be quantified, both in terms of the plant species displaced and affected wildlife.
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description.	(--) The species is difficult and costly to eradicate once established. Trends in landscape change and environmental degradation point towards an increase in potential *Ailanthus* habitat.
Potential for catastrophic impacts (H,M,L) and brief description	Low
Link to other Work Groups (e.g., socioeconomic impacts)	Potential economic impacts on the forest products / timber industry. The species' highly allergenic pollen as well as the tree's ability to damage urban sewer systems are both potential human health risks.
Extent to which threat is currently regulated or otherwise managed	Not regulated. Occasional local eradication projects undertaken.
Barriers to restoration	The species is a rapid invader, quickly overtaking disturbed sites. Eradication is labor-intensive, time-consuming, and potentially costly. Progeny source is well established and prevalent.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	L: Unmanaged lands.
Small business industry	L: Unmanaged lands.
Transportation	M: Roadsides, embankments, railroadsides.
Residential	M: Propagation of species as ornamental.
Agriculture	L: Old shelter belts, unmanaged field boundaries.
Recreation	L: Unmanaged lands, edges of rec. fields.
Resource extraction	M: Logged and mined lands.
Government	L: Open space purchases coupled with lack of management.
Natural sources/processes	H: Extant populations.
Orphan contaminated sites	NA
Diffuse Sources	

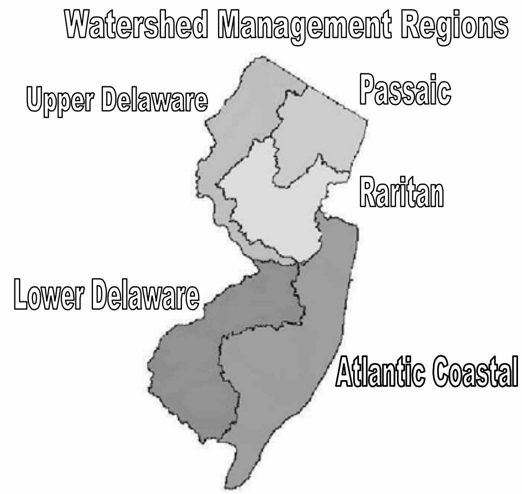
Sediment sinks	NA
Soil sinks	M: Seed bank.
Non-local air sources incl. deposition	NA
Biota sinks	NA

Issue: Tree-of-Heaven: *Ailanthus altissima*
Author: Matt Palmer & Tim Casey
Version: 3/27/00

Statewide Analysis of Threat

Threat = Invasive – Tree of Heaven

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	N/A	N/A	N/A	N/A
Wetlands	3	4	3	36
Forests	3	5	4	60
Grasslands	3	4	2	24



Total Score	120
Average Score (Total ÷ 5)	24

Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	N/A	M-H	H	M
Passaic	N/A	N/A	M-H	H	M
Raritan	N/A	N/A	M-H	H	M
Atlantic	N/A	N/A	M-H	H	M
Lower Delaware	N/A	N/A	M-H	H	M
Region/Watershed					

(secondary)					
Urban	N/A	N/A	M-H	H	M
Suburban	N/A	N/A	M-H	H	M
Rural	N/A	N/A	M-H	H	M

H=high, M=medium, L=low, NA = not applicable

References for *Ailanthus*

Davis D, Coppolino J. 1974. Relative ozone susceptibility of selected woody ornamentals. Hortscience. 9(6): 537-539.

Dirr MA. 1998. Manual of Woody Landscape Plants. Stipes.

Dutton B. 1996. Tree-of-heaven (*Ailanthus altissima* (Miller) Swingle). New York Metropolitan Flora, Brooklyn Botanic Garden.

Facelli J. 1994. Multiple indirect effects of plant litter affect the establishment of woody seedlings in old fields. Ecology. 75(6): 1727-1735.

Feret P. 1985. Ailanthus: variation, cultivation, and frustration. Journal of Arboriculture. 11(12):361-368.

Heisey R. 1996. Identification of an allelopathic compound from *Ailanthus altissima* (Simaroubaceae) and characterization of its herbicidal activity. Am. Journ. Bot. 83(2):192-200.

Hoshovsky M. Element Stewardship abstract for *Ailanthus altissima*. The Nature Conservancy.

Illick J. 1926. Common Trees of New Jersey. American Tree Association.

Lawrence J. 1991. Ecological impact of allelopathy in *Ailanthus altissima*. Am. Journ. Bot. 78:948-958.

Martine CT. 2000. Trees of New Jersey and the Mid-Atlantic States. NJDEP.

Rehder A. 1990. Manual of Cultivated Trees and Shrubs Hardy in North America. Dioscorides Press.

Santamour F. 1983. Woody plant succession in the urban forest: filling cracks and crevices. J. Arb. 9(10):267-270.

Invasive Plants -Native

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Phragmites Australis** (Cav.) Trin ex Steudel (Poaceae) – Common reed (Gleason and Cronquist 1991). Formerly known as *Phragmites communis* Trin.
Description of stressor	*P. australis* is a tall, erect perennial grass, growing to 14 or more feet, usually forming dense stands. It has thick rhizomes. It has long, flat, tapering leaves to 24 inches, arranged distinctly in two ranks. Flowers and seeds are borne on a branched terminal panicle with silky, brown hairs at stem. Flowers are purple when young and white when mature (Tiner 1993). In New Jersey, flowers are produced in early august, seeds are produced by September or October (Bart, unpublished data). The range of common reed in the North America is from Nova Scotia and Quebec south to Florida, Texas, and California (Tiner 1993). Although there is some debate about the introduction of new genotypes (Chambers et al. in press), peat core and archeological evidence suggests that it is native to the United States (Niering and Warren 1977). Nevertheless, the species enjoys a nearly worldwide distribution, occupying every continent except Antarctica (Haslam 1971). Although the plant produces prodigious seeds, up to 99% are nonviable, depending on the population. Most of the reproduction is vegetative, through vigorous rhizomatous spread or less frequently by stoloniferous spread (Haslam 1971). The result is often vast clones taking on appearance of an advancing front or else a centroid (personal observation). *P. australis* inhabits brackish and tidal fresh marshes in both regularly and irregularly flooded zones, in salt marshes along upland borders (Tiner 1993) and as advancing fronts from tide creeks, mosquito ditches, and other well drained features (Bart 1997, Bart and Hartman 2000). It is also found in non-tidal freshwater marshes, swamps, wet shores, roadside ditches, spoil embankments, and in general, disturbed moist areas (Tiner 1993, Marks et al. 1994). This species is difficult to confuse with any natives. Nevertheless, without inflorescence it can be confused on casual viewing with *Spartina cynosuroides* (Poaceae) in New Jersey's brackish marshes.
Stressor-specific impacts considered: Biological integrity Biodiversity	The impacts of *P. australis* are subject to debate, as much of the data collected are either anecdotal or else can be confused with the effects of associated anthropogenic disturbance (Bart 1997). Nevertheless, the suggested or proven effects of *P. australis* stem from the following factors: its association with anthropogenic disturbances, quick

Habitat/ecosystem health Ecosystem function	and dense rhizomatous spread, its dense stands and great height compared to other marsh vegetation, its ability to oxygenate its rhizosphere, its high productivity, and its effects on edaphic conditions. Its association with anthropogenic disturbances provides propagule dispersal to many suitable habitats, through rhizome fragmentation and movement (Bart 1997). Its tall height and dense stands tend to outshade native vegetation, creating monotypic stands (Windham 1995), however, some stands do not effectively outshade all vegetation, especially in areas of high sulfides (Bart, unpublished data). Species that are particularly at risk are low lying herbaceous species in salt and brackish water marshes (*Spartina patens, Distichlis spicata, Juncus gerardi,* and others). Its other effects are less certain, and may be system specific. In salt marshes, dense stands lower porewater sulfides (Bart and Hartman 2000), which might speed community level transitions. Some evidence suggests that it aids in nutrient retention due to its high productivity (Meyerson et al. a in press, Meyerson et al. b in press), and decreases ammonium concentration over native species in tidal marshes (Meyerson et al. b in press, Templer et al. 1998, Bart and Hartman 2000). However, much of the evidence for its effects on nutrient cycling in general (Meyerson et al. B in press) is based on correlational evidence and may be confounded with spatial heterogeneity in drainage (Bart and Hartman 2000). Nevertheless, it is plausible that increased soil oxygenation through pressure ventilation (Armstrong and Armstrong 1992) supports both increased nitrogen uptake and denitrification in wetland systems (but see Starink et al. 1999), especially when it lowers sulfide concentrations (Chambers 1997, Bart and Hartman 2000). There is some evidence to support claims that the plant is decreasing microtopographic relief while increasing overall elevation in brackish and salt marshes (Windham 1995, Windham and Lathrop in press), although the evidence is based on possibly confounded correlations, and in some marshes the invaded areas inhabit significantly lower elevations than uninvaded areas (Bart and Hartman 2000, Montalto, pers. comm.). In marshes that exhibit this rise in elevation, the invasion tends to create conditions in tidal marshes where creek banks have steeper slopes than normal, where *Spartina* sp. are fragmented with less interface between *Spartina* sp. and creeks, and creates small dikes (Wienstein and Balletto 1999). The result is possibly less habitat for transient fish species in tidal habitats. There is a lot of anecdotal and correlational evidence to suggest that with invasion, the avian fauna changes in composition (Marks et al. 1994). Furthermore, Benoit (1997) suggests tall, dense growth will limit bird use to creek edges, and may even inhibit edge use. He also found that Virginia rail is more abundant in native *Typha* vegetation than in invaded stands, and in general marsh specialists are far less common in invaded marshes. Mammals such as muskrats do not enter thick stands, but stands artificially fragmented with watercourses do not have as great an effect (Widgescog pers. comm.) In general, *Phragmites* is not good forage for mammals because its leaves are highly siliceous (Kiviat 1994), however, the rhizomes are palatable. It seems that *P. australis* increases the severity and frequencies of fires in salt hay fields, although the evidence is anecdotal (Bart 1997). The invasion has had a severe economic effect on salt hay farmers, who in some cases have lost more than 50% of their fields to the invasion (Bart 1997).
Key impacts selected (critical ecological effects)	Reduces abundance of native plant species.

	Changes faunal composition. Effects transient fish in tidal wetlands. Agricultural weed in salt hay farms. Changes biogeochemical cycling and soil quality. Has site specific effects on water quality.
Exposure Assessment	
Exposure routes and pathways considered	Wind disperses seeds (Haslam 1971). Construction activities, maintenance of mosquito ditches, and large hurricanes fragment and disperse rhizome fragments. This last grouping of dispersal agents might be more important for the invasion, as rhizomes carry photoassimilate and osmoregulatory ions that makes emerging culms more tolerant of flooding and salt concentrations (*sensu* Hellings and Gallagher 1992, Matoh et al. 1988).
Population(s)/ecosystem(s) exposed statewide	All wetland habitats and disturbed moist areas, especially hydrologically altered salt and brackish water marshes and fresh water tidal marshes (Chambers et al. in press, Marks et al. 1994).
Quantification of exposure levels statewide	No quantification at this time, although Chambers et al. (in press) lists statistics for some marshes.
Specific population(s) at increased risk	High marsh communities of brackish and salt marshes are at risk of invasion, but many stands resist complete coverage (Bart, unpublished data). *Typha* sp. Populations are also invaded in tidal freshwater marshes. Other communities may also be at risk.
Quantification of exposure levels to population(s) at increased risk	Reports of rates of invasion in high marsh communities tend to be on site specific basis. See Windham and Lathrop (in press) for rates at Hog Island in the Mullica river, Chambers et al (in press) for other New Jersey sites, and Shanks (unpublished data) for the Hackensack Meadowlands.
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	Quantifications of changes in species diversity, elevation changes (Windham and Lathrop in press), sulfide concentrations (Bart and Hartman 2000), and nutrient cycling (Meyerson et al. b (in press), Windham 1998) exist for specific sites, but it would be ill advised to extrapolate across systems or even within system types.
Risk Characterization	

Issue: Phragmites
Author:
Version:

Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	While no species are threatened, there is almost always a major community and ecosystem level shift. There is evidence that habitat is lost for select avian species, and possibly for larval fish in tidal systems. The invasion is not reversible in the short run without major alterations in hydrology (Chambers 1997) or spraying with glyphosate herbicides. Even with control measures, re-invasion can occur.	3
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Future infestations and rhizomatous spread into new areas are very likely if not inevitable.	5

Issue: Phragmites
Author:
Version:

Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	Personal observations have shown many tidal marshes, riparian systems, disturbed land, and standing fresh water with at least isolated clones. However, it is not certain in many cases if these clones are invasive or are stable.	2
	Total	30
Assessment of uncertainties in this assessment (H,M,L) and brief description	M: Information on effects is often based on anecdotal or correlational evidence alone. Effects on fish populations and avian fauna may be confounded with the effects of associated disturbances such as tide restriction. Effects on nutrient cycling and soil qualities might be confounded with pre-existing heterogeneity within the site. Site specific estimates spread rates are often based on limited sequences of aerial photographs. The effects of the plant on nutrient cycling are probably site specific.	
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description. (Data Gaps; highlight significant data needs)	H: Better quantification of rate of spread, more experimental evidence of its effects on nutrient cycling and fish habitat, more experimental evidence is needed to disentangle the effects of the invasion from the effects of salt hay farming, tide restriction, ditching, and other often associated disturbances are needed. Also, more information on the effects of the invasion in non-tidal systems is needed.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, , =, where + is improvement), and brief description.	-: The invasion is expected to proceed, following disturbances and spreading vigorously into new areas.	
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	L: Potential for short-term drastic impacts are low. Although the invasion does outcompete native plant species, it does not presently affect endangered populations. Remnant native species patches may allow for the survival of native fauna.	
Link to other Work Groups (e.g., socioeconomic impacts)	The invasion has damaging effects on salt hay farming.	
Extent to which threat is currently regulated	There are no regulations limiting the propagation and use of *P. australis.* Wharton State Forest has recently initiated a program for control of small populations of Phragmites (R. Cartica, pers. comm.).	
Barriers to restoration	There are many large and scattered populations, some of which occupy huge areas. Coupled with the expensive or ecologically questionable control methods usually employed and the fact that it is a native species, eradication is neither possible nor desirable. Efforts should be focused on preventing new areas from becoming invaded and in eradicating invasive stands where it threatens major flyways for waterfowl, populations of marsh specialist birds, or salt hay farms. Due to soil mobilization, contaminated sites probably should not be targeted for restoration.	
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources		
NJ Primary Sources		
Large business/industry	H: Filling for any construction activity and the creation of spoil piles creates conditions where *P.australis* can	

	invade wetlands.
Small business industry	H: Same as above.
Transportation	M: Disturbance created by road maintenance favor invasion.
Residential	L: There is no residential use of the plant.
Agriculture	H: Salt hay farming and associated ditching and tide restriction promote invasion, upland farming promotes invasion near streams.
Recreation	L: Duck hunters use stolons as blind material.
Resource extraction	N/A
Government	H: Mosquito control through ditching and ditch maintenance promotes propagule dispersal and creates better-drained areas for establishment in salt marshes.
Natural sources/processes	H: Hurricanes spread rhizome fragments, established populations will continue to spread.
Orphan contaminated sites	H: Meadowlands sites are frequently invaded
Diffuse Sources	
Sediment sinks	N/A
Soil sinks	Buried rhizome fragments are the best forms of propagation.
Non-local air sources incl. deposition	Large hurricanes and tides have the potential to raft in rhizomes.
Biota sinks	Probably none

Issue: Phragmites
Author:
Version:

Statewide Analysis of Threat

Threat = Invasive – *Phragmites australis*

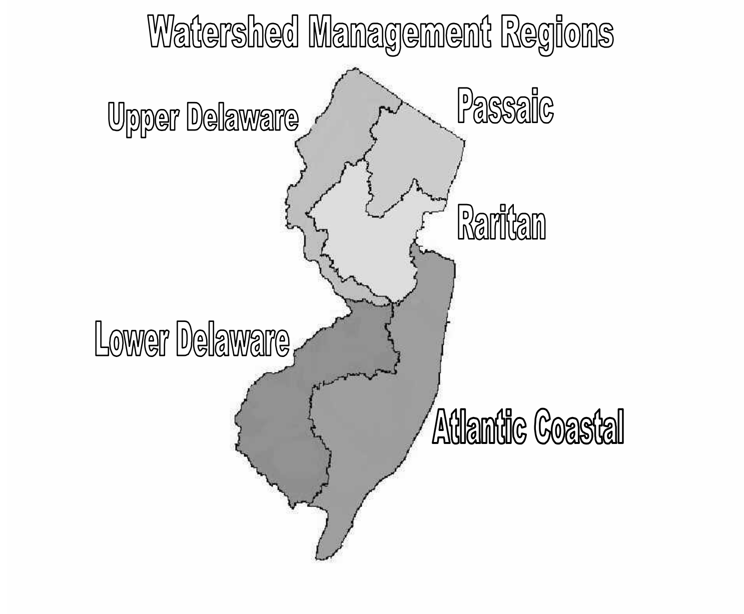
Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	N/A	N/A	N/A	N/A
Wetlands	3.5	5	4	70
Forests	3.5	2	2	14
Grasslands	3.5	2	2	14
			Total Score	98
			Average Score	19.6

Risk by Watershed Management Region

THREAT = P*hragmites australis*	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	N/A	H	L-M	L-M
Passaic	N/A	N/A	H	L-M	L-M
Raritan	N/A	N/A	H	L-M	L-M
Atlantic	N/A	N/A	H	L-M	L-M
Lower Delaware	N/A	N/A	H	L-M	L-M
Region/Watershed (secondary)					
Urban	N/A	N/A	H	M	M
Suburban	N/A	N/A	H	M	M
Rural	N/A	N/A	H	M	M

H=high, M=medium, L=low;

Issue: Phragmites
Author:
Version:



References

Armstrong J., Armstrong, W., and Beckett, P. 1992. *Phragmites australis*: Venturi – and humidity – induced pressure flows enhance rhizome aeration and rhizosphere oxidation. - New Phytologist 120: 197-207.

Bart, David J. 1997. The Use of Local Knowledge in Understanding Ecological Change: A Study of Salt Hay Farmers' Knowledge of *Phragmites australis* Invasion. Unpublished MA, Rutgers the State University of New Jersey.

Bart, D.J. and Hartman, J.M. 2000. Environmental determinants of *Phragmites australis* expansion in a New Jersey salt marsh: an experimental approach. - *Oikos* 89: 59-69

Benoit, L.K. 1997. Impact of the spread of *Phragmites* on populations of tidal marsh birds in Connecticut. Unpublished MA Thesis, Connecticut College, New London, CT.

Chambers, R.M. 1997. Porewater chemistry associated with *Phragmites* and *Spartina* in a Connecticut tidal marsh. - Wetlands 17: 360-367.

Chambers, R.M. Meyerson, L.A., and Saltonstall, K. In Press. Expansion of *Phragmites australis* into tidal wetlands of North America. – *Aquatic Botany.*

Fürtig, K., Rüegsegger, A., Brunold C., and Brändle, R. 1996. Sulphide utilization and injuries in hypoxic roots and rhizomes in common reed (*Phragmites australis*). - Folia Geobotanica Phytotaxonomia 31: 143-151.

Haslam, S.M. 1971. Biological flora of the British Isles: *Phragmites communis* Trin. *Annals of Botany* 33: 289-301.

Hellings, S.E. and Gallagher, J.L. 1992. The effects of salinity and flooding on *Phragmites australis*. – *Journal of Applied Ecology* 29: 41-49.

Kiviat, E. 1994. Reed, sometimes a weed. – *Hudsonia* 10: 4-6.

Marks, M., Lapin, B. and Randall, J. 1994. *Phragmites* (P. communis): threats, management, and monitoring. – *Natural Areas Journal* 14: 285-294.

Matoh, T., Matsushita N., and Takakashi, E. 1988. Salt tolerance of the reed plant *Phragmites communis*. - Physiologia Plantarum 72: 8-14.

Meyerson, L.A., Chambers, R.M., and Vogt, K.A. In Press. Effects of *Phragmites* removal on nutrient pools. – *Biological Invasions*

Meyerson, L.A., Saltonstall, K., Windham, L., Kiviat, E. and Findlay, S. In Press. A comparison of *Phragmites australis* in freshwater and tidal brackish marsh environments in North America. – *Wetlands Ecology and Management*.

Niering, W.A., and Warren, R.S. 1977. Our dynamic tidal marshes: vegetation changes as revealed by peat analysis. – *Connecticut Arboretum Bulletin* 12: 22 pp.

Roman, C.T., Niering, W.A., and Warren, R.S. 1984. Salt marsh vegetation change in response to tidal restriction. - Environmental Management 8: 141-150.

Starink, M., van Rijswijk, P. Middelburg, J. and Cappenberg, T. 1999. Nitrification- denitrification in the rhizosphere of emergent macrophytes: fiction or facts?. – Paper presented at 1999 EUREED conference, Czechoslovakia.

Templer, P., Findlay, S. and Wigand, C. Sediment chemistry associated with native and non-native emergent macrophytes in a Hudson River marsh ecosystem. – *Wetlands* 18: 70-78.

Tiner, R.W. 1993. Field Guide to the Coastal Wetland Plants of the Southeastern United States. University of Massachusetts Press: Amherst

Weinstein, M.P. and Balletto, J.H. 1999. Does the common reed, *Phragmites australis*, affect essential fish habitat? – *Estuaries* 22: 793-802.

Windham, L. 1995. Effects of *Phragmites australis* on above ground biomass and soil properties in brackish tidal marsh of the Mullica River, New Jersey. Unpublished M.S. Thesis, Rutgers University, New Brunswick, NJ.

Windham, L. and Lathrop, R.G. In Press. Effects of *Phragmites australis* (Common Reed) Invasion on Aboveground Biomass and Soil Properties in Brackish Tidal Marsh of the Mullica River, New Jersey. – *Estuaries.*

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	**Lead (Organic and Inorganic)**
Stressor Description of stressor	Lead, with atomic number 82 and atomic weight of 207.19, is a bluish-white, gray metal which is lustrous when freshly cut, and emits dangerous, highly toxic fumes when heated (Prater 1995). It is soft, malleable, easily melted, cast and rolled, and tarnishes when exposed to air. Lead occurs in an inorganic form (Pb II and Pb IV) and in an organic form. It is the inorganic lead that is circulated atmospherically, and leaded fuel accounts for the greatest input atmospherically (Pain 1995). Lead is naturally occurring, is an important constituent of over 200 minerals, and its average concentration in the Earth's crust is 16mg/Kg soil (EPA 1980, Pain 1995). Lead can be released into the environment by natural processes, such as weathering of rocks, volcanic activity, forest fires, and radioactive decay (Pain 1995). Lead in the environment, however, is largely anthropogenic, and man's activities have resulted in levels in water and soil that are several orders of magnitude above natural levels (Pain 1995). Lead levels in soil of urban areas can be as high as 5,000 mg/KG, and in water they can be as high as 10 µg/L (Royal Commission 1983), and with global transport, rural areas and arctic environments have elevated lead levels (Pain 1995). There are no longer natural environmental concentrations because anthropogenic emissions are ubiquitous (Pain 1996). Lead was used by the Egyptians 7000 years ago for weights and anchors, solder, pottery glaze, and for cooking utensils and pipes. It was also used by the Romans, and is credited with their downfall since high lead levels have been found in the bones of exhumed Romans (Gilfillan 1965). Today, lead is used in construction for tank linings, piping, equipment handling corrosive gases and liquids, for X-ray and atomic radiation protection, in manufacturing, for metal alloys, manufacturing of some paints and pigments, and in gasoline in some parts of the world, in ceramics, in lead storage batteries, and as a solder, cable covering, and sheet lead (Prater 1995). In 1995, about 4 million tons of lead are refined annually worldwide, and storage batteries account for the largest use (Eisler 1988). The biogeochemical cycles of lead have been affected by man to a greater degree than any other toxic element (Jaworski 1987). Most of the lead in the open oceans comes from atmospheric deposition, rather than run-off from rivers (Jaworski 1987). Lead is a nonessential, highly toxic heavy metal that affects all body systems, and all known effects on biological systems are detrimental (Pain 1995, 1996). Organolead compounds are more toxic than inorganic lead compounds, and young animals are more sensitive than older animals (Eisler 1988). Exposure to lead can be chronic or acute, and there is no "no effect" level since the lowest measurable lead concentrations have been shown to affect some biological systems, although often there are no clinical symptoms (Franson 1996). At higher levels, lead poisoning occurs, and such mortality has been recorded in a wide diversity of vertebrates (Eisler 1988, Prater 1995). Lead levels increase with age and size in fish (Thompson 1990).

Description of stressor [continued]	Plants are relatively tolerant of lead, largely because many plants have a mechanism for storing lead in an insoluble form (Pain 1995). Algae are the most tolerant of lead (Pain 1995). At very high levels, lead causes disruption of cell membranes, inhibition of growth, reduction of photosynthesis, water absorption and transpiration, and a decrease in pollen germination (Eisler 1988, Pain 1995). Plants can absorb lead from the soil and air (Kabata-Pendias and Pendias 1984), and lead remains in leaf litter for long periods (half-life of 220 years, Eisler 1988). Lead can reduce populations of soil decomposers, such as fungi, earthworms and arthropods (Eisler 1988). Lead is toxic to all phyla of aquatic invertebrates, although toxicity levels vary by species, water temperature (more severe effects at higher temperatures), pH (reduced pH more severe), and by life stages (younger animals more affected, Eisler 1988). Lead can cause increased mucus formation in fish, leading to decreased respiration and resulting in death by anoxia. Lead also causes spinal curvatures, anemia, destruction of spinal neurons, ALAD inhibition in several tissues, reduced swimming ability, destruction of respiratory epithelium, muscle atrophy, paralysis and reproductive disorders (Eisler 1988). Amphibians and reptiles also experience lead poisoning, including sluggishness, erosion of gastric mucosa, and muscular twitching (Eisler 1988). Birds and mammals are particularly at risk from lead exposure, especially during development, although direct mortality from lead exposure has also been reported. Ducks and other waterfowl, and doves and other species that eat grit, are particularly vulnerable to lead from lead shot and anglers lead weights (Pain 1996, Burger et al. 1997). Over 30 species of birds have died from lead poisoning (Franson 1996). Other birds, however, are also vulnerable to lead, particularly to low level, chronic exposure, which affects neurobehavioral development and reproduction for several generations (Eisler 1988, Burger 1995). Symptoms of lead poisoning include drooped wings, loss of appetite, lethargy, weakness, emaciation, tremors, green feces, impaired locomotion, balance, and depth perception (Sileo and Fefer 1983, Eisler 1988, Burger and Gochfeld 1994, 1997a). While lead poisonings that derived from lead shot were commonly reported before lead shot for waterfowl was banned (Eisler 1988), cases of mortality from lead poisoning are rare otherwise. However Sileo and Fefer (1983) reported that some Laysan albatross, Diomedea immutabilis, chicks on Midway Atoll suffered lead poisoning from eating paint chips that were flaking off buildings. Lead affects a wide range of systems in birds and mammals, including the central nervous system, kidneys, hematopoietic system, cardiovascular system, and gastrointestinal tract (Ma 1996, Pain 1996). Sub-acute effects can include behavioral modification, and chronic low-level lead during development causes growth deficits and irreversible brain developmental effects that result in neurobehavioral deficits (Ma 1996, Eisler 1988, Burger and Gochfeld 1997a, 2000). Although muscle levels of lead tend to be low (range of 1-2 ug/g wet weight), lead accumulates at much higher levels in bone (Thompson 1990). Lead levels are highest in bone in birds and mammals (Burger 1993), and can be mobilized from bone under some conditions. Lead bioaccumulates and bioconcentrates in all organisms, with a high degree of organ specificity (Eisler 1988, Prater 1995); lead levels increase with age and size in fish (Thompson 1990).

Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	The impacts considered are to species behavior and survival, population levels, biological integrity, and biodiversity. Lead levels elevated beyond natural background levels may cause acute and chronic toxicity, leading to changes in the behavior, reproductive success, composition, diversity, and functioning of plants and animal populations and communities. All ecosystems are at risk as lead is ubiquitous throughout the world, including the arctic, where lead concentrations are now 10 to 100 times higher than in prehistoric times (Jaworski 1987).
Key impacts selected (critical ecological effects)	Key impacts evaluated are sublethal behavioral and reproductive effects, death and population declines, biological integrity, and biodiversity. Because of the extensive laboratory work, especially with vertebrates, tissue concentrations can be used as a bioindicator of adverse health effects on a wide range of species.
Exposure Assessment	
Exposure routes and pathways considered	Exposure pathways result from anthropogenic sources on top of natural levels. Localized contamination of environmental media near industrial sites, roadways (leaded fuel), and urban areas (lead paint, batteries) can cause problems for a wide range of species. Soil contamination is caused by direct placement of hazardous waste sites, discharges, emissions from leaded gasoline, and other industrial uses. Aquatic contamination is via point and non-point source pollution, effluents, surface water run-off, direct discharge of contaminated groundwater, leaching from contaminated fill, and atmospheric deposition. Exposure media include soil, air, surface water, sediment, and food.
Population(s)/ecosystem(s) exposed statewide	All ecosystems in the state are exposed to lead because of the high anthropogenic uses, and atmospheric deposition. Removal of lead from gasoline has greatly reduced airborne lead levels and deposition, but point sources remain in many areas. Anthropogenic inputs have resulted in elevated lead levels in all regions of the state, in all surface waters, and in all soils and sediments. Although contamination is often greatest in urban/suburban regions, elevated lead levels are found throughout the state.

Quantification of exposure	BackGround in U.S. Ambient concentrations of lead in environmental media result from weathering of parent geological media, volcanic action, radioactive decay, and anthropogenic sources, which include atmospheric deposition. In the mid-1980s, lead concentrated in the U.S. were estimated as follows (Royal Commission 1983). Air: Rural/remote - 01-100 ng/m^3 Urban - 0.1-10ug/m^3 Soil: Rural/remote - 5-50 ug/g Urban -10-5,000 ug/g Water: Fresh - 0.005-10 µg/L Salt - 0.005-0.015 µg/L STATE BACKGROUND LEVELS (Fields et al. 1993) A study of background levels was carried out, using 80 soil samples of New Jersey's most common soil types. Overall mean values for lead in soil was 58.4 mg/KG. By region, as follows: Urban 112.9 mg/KG (dry weight) Suburban 19.0 Rural 11.1 Golf Courses 8.0 Farm 19.6
Quantification of exposure [continued]	Benchmark Values Soil: 500 mg/KG (Efroymson et al. 1997; tested for earthworms). Upper Piedmont: 138.9 mg/Kg (Wong & Sanders 1998). Sediment: freshwater: 31 mg/KG, dry weight (LEL), and 250 mg/KG, dry weight (SEL) (Persaud et al. 1993). marine/estuarine: 47 mg/KG, dry weight (ER-L), and 218 mg/KG, dry weight (ER-M)(Long et al. 1993). Surface Water: Freshwater chronic criteria for lead is 2.5 µg/L; for salt water it is 24 µg/L (draft, NJ Water Quality Criteria). Plant tissues: screening benchmark for phytotoxicity in soil = 50 mg/KG and in solution = 0.02 mg/L (Efroymson et al. 1997b)

	Invertebrates: interpreting levels of all metals, including lead, in invertebrates is difficult because toxicity occurs when the rate of uptake exceeds the rates of detoxification and/or excretion, rather than at absolute body concentrations (Rainbow 1996). Thus one invertebrate with a lower level of lead may suffer from toxicity while another of the same species has a higher level accumulated in a detoxified form over an extended period. Fish Tissue: For Mummichogs (Fundulus heteroclitus), the LC50 (96 hours exposure) was 316 μg/L (Eisler 1988). Bird Tissue: levels of 4 ppm in feathers have been associated with sublethal neurobehavioral deficits in birds in laboratory studies (Burger 1995, Burger and Gochfeld 2000), as well as in nature (Burger and Gochfeld 1994, 1996, 1997a). Levels of lead in the liver of from 2 ug/g (for Precellariiformes) to 40 ug/g (for Ciconiiformes) cause mortality in birds (Franson 1996). Mammalian Tissues: liver levels of 30 ug/g dry weight, or kidney levels of 90 ug/g of dry weight and above are associated with clinical signs of lead poisoning (Ma 1996). Given that there are species differences in response to lead, levels of 10 ug/g dry weight in the liver and levels of 25 ug/g in the kidney can be used to diagnose acute lead poisoning in mammalian wildlife (Ma 1996).)
Specific population(s) at increased risk	High lead levels can cause declines in the populations of decomposers in the soil, such as earthworms, fungi, and arthropods (Eisler 1988), thereby having an overall ecosystem effect. Because of bioaccumulation and biomagnification, vertebrates, particularly birds and mammals, are particularly at risk from lead exposure. Birds and mammals that are more at risk include those that are exposed to lead shot (either through being shot or consuming soil or sediment with lead pellets), those that ingest birds or mammals that carry lead shot, domestic livestock and other grazers that live near smelters, refineries and lead battery recycling plants (Eisler 1988). While there have been cases of mortality due to lead toxicity in birds and mammals, acute toxicity is usually less of a problem. For birds and mammals, and perhaps other terrestrial animals, chronic low-level lead exposure is of greater concern than acute poisoning because of the irreversible of effects, and the diffuse nature of environmental contamination (Ma 1996).

Quantification of exposure levels to population(s) at increased risk	Levels of lead present in various ecosystems in the state are presented to provide a picture of overall ecosystem levels. Inland Waters (11 sites). No detectable levels for surface waters in 5 samples, mean of 22.6 µg/L for detectable samples. Detectable levels for sediment concentrations in all 11 sites; lead for sediment = 6715.2 mg/KG. However, removing one high value of 71,903.3 (from Hanover Lake, Mirror Lake etc from Fort Dix) yields a mean of 178.5 mg/KG (Baseline Ecological Evaluations). Fresh Water Wetlands (4 sites available) Surface water concentrations for one site (644 µg/L). Wetland soil concentration given for three sites, mean lead of 1706 mg/KG (Baseline Ecological Evaluation data set). Estuarine Ecosystems 1. Newark Bay: Surface waters - range of 0.162 - 0.456 µg/L (mean of 0.333 for 12 time periods (GLEC 1996) Sediment - 194 mg/KG (Adams et al., 1998) Sediment - 133 mg/KG (GLEC 1996) 2. Lower Harbor: (includes Raritan and Sandy Hood Bays): Sediment - 64 mg/KG (Adams et al., 1998). 3. Passaic River Study Area, 1996). Total lead in water, values range from 1-30, with over half less than 1µg/L (NOAA 1999). Surface waters - range of 0.183 - 1.150 µg/L (mean of 0.752 for 12 time periods (GLEC 1996) Average sediment lead levels of 345 mg/KG (range: 0.15-369) (NOAA 1999). Sediment 330 ug/g (GLEC 1996). 4. Hackensack River Surface waters - range of 0.151 - 0.696 µg/L (mean of 0.371 for 12 time periods (GLEC 1996) Sediment - 150 ug/g (GLEC 1996). 5. Lower Delaware River Sediment samples: range from 15.3 to 397 mg/KG (mean of 99.2 mg/KG for 24 samples)(DRBC 1993)

Quantification of exposure levels to population(s) at increased risk [continued]	6. Lower Raritan River Surface water: Expressed as range based on data from three contaminated sites. Lead ranged from 25- 183 mg/KG. Sediment range from 2 - 906 mg/KG (R. F. Weston, 1996). Surface waters - range of 0.07 - 0.658 µg/L (mean of 0.207 for 12 time periods (GLEC 1996) Sediment: range from 78 - 907 mg/KG (mean of 268.9, 10 sites, CDM 1999). Sediment in Raritan River - 55.9 ug/g (GLEC 1996). 7. Raritan Bay Surface waters - range of 0.05 - 0.216 µg/L (mean of 0.11 for 12 time periods (GLEC 1996) Sediment - 190 ug/g (GLEC 1996). 4.5 ug/g for some young birds. 1990 mean of 1.5 ug/g, with some values ranging up to 3.70 (Burger 1997). Common Tern = 1999 mean of 2.0 ug/g, but some birds ranged to 4.7 ug/g (Burger, unpub. data). Eggs from birds: Common Tern = 1989 means of 0.25 ug/g (Burger 1993) 1999 means of 1.0 to 2.70 ug/g (Burger, unpubl data). Herring Gull = 1989 mean of 5.86 ug/g (Burger and Gochfeld 1993). Herring Gull 1989 mean = 2.10 ug/g (Burger and Gochfeld 1993), 1.5 ug/g (Burger 1997). However, levels ranged up to 8. Atlantic Coastal Waters (Bight Apex, EPA 1997) Surface Water = 0.046 + 0.11 µg/L 9. Urban Piedmont (Wong and Sanders 1998) Soil = 138.9 ug/g (mean)

	8. Barnegat Bay Feathers from birds: Urban/Terrestrial Ecosystems Organisms at Risk Birds and Mammals. Because of the high potential for bioaccumulation and biomagnification up the food chain, and because of their higher sensitivity, birds and mammals are particularly at risk. While lead can cause outright mortality, chronic exposure is the more serious problem because of the irreversible effects on developing fetuses and young. This sensitive group suffers potentially severe and irreversible effects to neurobehavioral development and cognitive function (Eisler 1988, Burger and Gochfeld 2000). Ecosystems at Risk Lands around lead smelters and coal gas sites are ecosystems particularly at risk because of high lead levels. However, the ubiquitous nature of lead exposure and the lack of any soils or waters with natural levels of lead (Pain 1996), and the continued atmospheric deposition of lead, all ecosystems are at risk from lead.
Dose/Impact-Response Assessment Quantitative impact-assessment employed	Statewide average concentrations of lead, or local levels, were compared to screening benchmark values to assess the risk to organisms living in New Jersey's ecosystems. Benchmarks for soil, sediment, surface water, and plant and animal tissue levels were compared to available data on lead concentrations for these matrices. The hazard quotient (HQ) method was used to conduct a screening level risk assessment where: $HQ = \frac{\text{Estimated Environmental Concentration}}{\text{Benchmark Concentration}}$ This approach assumes that concentrations of the contaminant were representative of the exposure to biota in the ecosystems evaluated. HQ values < l indicate lead concentrations are at a level where adverse effects are not expected and there is little risk. Values > 1 indicate that lead concentrations are at a level where adverse effects may potentially occur, and there is potential risk to ecological receptors, which increases with level of the food chain.
Risk Characterization	

Issue: Lead
Author: Burger
Version: 06/07/00

Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)	1. Statewide Ambient	Score
	Sediment	
	Urban $HQ = \frac{112.9\ mg/KG}{31.0\ mg/KG} = 3.64$	2
	Suburban $HQ = \frac{19.0\ mg/KG}{31.0\ mg/KG} = 0.6$	1
	Rural $HQ = \frac{11.1\ mg/KG}{31.0\ mg/KG} = 0.36$	1
	Golf Courses $HQ = \frac{8.0\ mg/KG}{31.0\ mg/KG} = 0.26$	1
	Farm $HQ = \frac{19.6\ mg/KG}{31.0\ mg/KG} = 0.63$	1
	2. Total Lead Associated with Contaminated sites and/or enriched urban/industrial settings:	
	Inland Fresh Water:	
	Surface Water: HQ = 0 (half were non-detect sites) to	
	$HQ = \frac{22.6\ \mu g/L}{2.5\mu g/L} = 9.04$	3
	Sediment: from $HQ = \frac{178.5\ mg/KG}{31.0\ mg/KG} = 5.76$	3
	to $HQ = \frac{6715\ mg/KG}{31.0\ mg/KG} = 216.6$ (*includes highly contaminated site*)	5
	Freshwater Wetlands:	
	Surface Water: HQ = 0 (most sites were non-detect) to	
	$HQ = \frac{644\ \mu g/L}{2.5\ \mu g/L} = 257.6$ 47 mg/KG	5

Risk estimate(s) by population at risk [continued] Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)	Sediment: HQ = 1703 mg/KG = 54.9 31.0 mg/KG Estuarine Ecosystems: 1. Newark Bay Surface Water: HQ = 0.333 µg/L = 0.0138 24 µg/L Sediment: HQ = 133 mg/KG = 2.83 2. Lower Harbor Surface Water: no data given Sediment: HQ = 64 mg/KG = 1.36 47 mg/KG 3. Passaic River: Surface Water: HQ = 0.752 µg/L = 0.031 24 µg/L High of 30 µg/L = 1.25 24 µg/L Sediment: HQ = 330 mg/KG = 7.02 47 mg/KG	Score 2 1 2 3

	4. Hackensack River	1	
	Surface Water: $HQ = \frac{0.31\ \mu g/L}{24\ \mu g/L} = 0.003$	2	
	Sediment: $HQ = \frac{150\ mg/KG}{47\ mg/KG} = 3.19$		
	5. Lower Delaware River	2	
	Surface Water: $HQ = \frac{99.2\ \mu g/L}{24\ \mu g/L} = 4.13$	2	
	Sediment: $HQ = \frac{99.2\ mg/KG}{47\ mg/KG} = 2.11$	2	
	6. Lower Raritan River	1	
	Surface Water: $HQ = \frac{0.207\ \mu g/L}{24\ \mu g/L} = 0.009$	3	
	High value from one site $= \frac{183\ \mu g/L}{24\ \mu g/L} = 7.63$	3	
	Sediment: $HQ = \frac{268.9\ mg/KG}{47\ mg/KG} = 5.72$		
	7. Raritan Bay	1	
	Surface Water: $HQ = \frac{0.11\ \mu g/L}{24\ \mu g/L} = 0.0046$	2	
	Sediment: $HQ = \frac{190\ mg/KG}{47\ mg/KG} = 4.04$		

Risk estimate(s) by population at risk [continued] Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)	8. Barnegat Bay For bird tissues: although the means for both eggs and feathers are below the sublethal effects levels, for some species, individuals are higher. Below the HQ is computed using the maximum values, although the HQs for means would be below 1. Herring Gull feathers HQ = 4.5 ug/g = 1.13 4.0 ug/g Common Tern feathers HQ = 4.7 ug/g = 1.18 4.0 ug/g 9. Atlantic Coastal Waters Surface Water: HQ = 0.11 µg/L = 0.005 24 µg/L 10. Urban Piedmont Sediment: HQ = 138.9 ug/g = 2.96 47.0 ug/g RISK SCORES: HQ SCORE < 1 1 1-5 2 6-10 3 11-25 4 25+ 5	Score 1 1 1 2

Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: - many species threatened/endangered - major community change - extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: - all habitats intact and functioning - population abundance and distributions reduced Short time for recovery	See attached Table for statewide analysis	
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 - Occasional 2 - Rare 1 - Possible in the future 0 - Unlikely (or 0.1)	See attached Table for statewide analysis	

Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	See attached Table for statewide analysis	
	Total	

Assessment of uncertainties in this assessment (H,M,L) and brief description	There is moderate uncertainty with this assessment, largely due to the infrequent sampling of media and the spatial extent of the sampling. There is data on statewide sampling, and on surface water, sediment and tissues (fish and other vertebrates), but no overall, carefully-designed sampling scheme. All habitats in the state are not covered equally. Some of the data had detection limits that were greater than the screening criteria. The risk to grazing animals and vertebrates may be underestimated because of the potential for chronic, sublethal neurodevelopmental effects, which are irreversible.
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	Unfortunately there is no regular monitoring of lead levels in the state in any media (surface water, sediment, soil), and no regular monitoring of biota that would be necessary to examine risks. Monitoring of indicator vertebrates should be undertaken, particularly given the potential for chronic effects, the high residual lead levels in soil, and atmospheric deposition. Given the high HQs for sediment, additional work with benthic invertebrates that live in sediment is essential. Additional data may change the risk estimates, particularly for vertebrates. Additional data from invertebrates and aquatic vertebrates are essential to understand the risk to wildlife populations from lead in the environment.

Issue: Lead
Author: Burger
Version: 06/07/00

Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡; where + is improvement), and brief description.	(–) The potential for significant future change in the underlying risk for lead exists. Lead does not degrade, and continued point-source and non-point source pollution, in addition to atmospheric deposition, will result in increased levels in soil, surface waters, and sediments, with increased exposure to vertebrates that are most at risk. Unless steps are taken to reduce sources, impacts on vertebrates may increase in the future.
Potential for catastrophic impacts (H,M,L) and brief description	The potential for catastrophic impacts to NJ's ecosystems and associated biota is considered low based on current releases rates, the fate of lead, and current knowledge of the adverse effects. However, this required continued vigilance and attendance to local anthropogenic sources.
Link to other Work Groups (e.g., socioeconomic impacts)	Potential socioeconomic impacts of lead contamination include decreases in population levels of some vertebrates, and potential losses of biodiversity.
Extent to which threat is currently regulated or otherwise managed	Control of lead discharges and the remediation of lead-contaminated hazardous waste sites are regulated under the Industrial Site Recovery Act (ISRA), Spill Compensation and Control Act, Solid Waste Management Act (SWMA), Water Pollution Control Act (WPCA), Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended by Superfund Amendments and Reauthorization Act of 2986 (CERCLA) and the Hazardous Site Discharge Remediation Act.
Barriers to restoration	Continued atmospheric releases and subsequent deposition from power plants and other industries provide a barrier to restoration.
Relative Contributions of Sources to Risk (H,M,L); include any information/ details on sources	The primary sources to NJ ecosystems appear to be atmospheric deposition, point source pollution from power plants, gasoline discharges (formerly), smelting and metallurgical activities, and from historical industrial discharges. The combination of atmospheric deposition, pollution, and run-off results in contamination of NJ's aquatic ecosystems, and soils around historical industrial sites. The "legacy" of lead accumulated in soil in cities and suburbs will remain for many years because of the use of lead-based paints and leaded gasoline (Jaworski 1987).
NJ Primary Sources	
Large business/industry	H: There are many sources of lead emissions to the atmosphere, and from point source pollution, including construction for tank linings, piping, equipment handling corrosive gases and liquids, for X-ray and atomic radiation protection, in manufacturing, for metal alloys, manufacturing of some paints and pigments, and in gasoline in some parts of the world, in ceramics, in lead storage batteries, and as a solder, cable covering, and sheet lead smelting, plating and other industries. These processes and products are used by many people in the state.
Small business industry	H: same as above.
Transportation	M: Lead is still used in some forms of gasoline, and is still contributing to atmospheric sources in other countries throughout the world.

Residential	M: but some use in paints, batteries that are carelessly discarded and other home uses.
Agriculture	L: mostly from past historical agricultural practices.
Recreation	L.
Resource extraction	L. (except where some vehicles still use forms of leaded gasoline).
Government	L.
Natural sources/processes	L: Lead is still released during erosion, from fires and from volcanic activity, which contributes to atmospheric deposition.
Orphan contaminated sites	M: This threat can be large, especially in places where soil is heavily contaminated from lead derived from industrial processes, leaded gasoline, and discarded paint products.
Diffuse Sources	
Sediment sinks	M. Historical industrial activity, including air and water discharges have resulted in elevated lead in sediments and water of aquatic systems.
Soil sinks	L. Except near industrial plants. M. Lead will remain a problem for many years to come because of the lead remaining in soil because of the ubiquitous use of lead-based paint and lead in gasoline, as well as from industrial processes.
Non-local air sources incl. deposition	M. Atmospheric deposition in the state is still problematic.
Biota sinks	M. Bioconcentration in aquatic organisms is key, particularly in vertebrates, which are more at risk than invertebrates.

REFERENCES

Adams, D. A. J. S. O'Connor, and S. B. Weisberg. 1998. Sediment quality of the NY/NJ Harbor system. Final Report. EPA/902-R=98-0011. Regional Environmental Monitoring and Assessment Program. USEPA.

Burger, J. 1993. Metals in avian feathers: bioindicators of environmental pollution. Rev. Environ. Toxicol. 5:203-311.

Burger, J. 1995. A risk assessment for lead in birds. J. Toxicol. Environ. Health 45:369-396.

Burger, J. 1997. Heavy metals and selenium in herring gulls (Larus argentatus) nesting in colonies from Eastern Long Island to Virginia. Environ. Monit. Assess. 48:285-296.

Burger, J. and M. Gochfeld. 1993. Lead and lead accumulation in eggs and fledging seabirds in the New York Bight. Environ. Monit. Assess. 12:261-267.

Burger, J. and M. Gochfeld. 1994. Behavioral impairments of lead-injected young Herring Gulls in nature. Fund. Appl. Toxicol. 23:553-561.

Burger, J. and M. Gochfeld. 1996. Lead and behavioral development: parental compensation for behaviorally impaired chicks. Pharm. Biochem. Behav. 55:339-349.

Burger, J. and M. Gochfeld. 1997. Lead and neurobehavioral development in gulls: a model for understanding effects in the laboratory and the field. Neurotoxicology 18:495-506.

Burger, J. and M. Gochfeld. 2000. Effects of lead on larids: a review of laboratory and field studies. J. Tox. Environ. Health. Part B. 3:59-78.

Burger, J., R. A. Kennamer, I. L. Brisbin Jr. and M. Gochfeld. 1997. Metal levels in Mourning Doves from South Carolina: potential hazards to doves and humans. Environ. Res. 75:173-186.

DRBC (Delaware River Basin Commission). 1993. Sediment contaminants of the Delaware River Estuary. West Trenton, New Jersey.

Efroymson, R. A, M. E. Will, and G. W. Suter II. 1997a. Toxicological benchmarks for contaminants of potential concern for effects on soil and litter invertebrates and heterotropic process: 1997 Revision. Oak Ridge, Tenn.

Efroymson, R. A, M. E. Will, G. W. Suter II, and A. C. Wooten. 1997b. Toxicological benchmarks for contaminants of potential concern for effects on terrestrial plants: 1997 Revision. Oak Ridge, Tenn.

Eisler, R. 1988. Lead hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish & Wildlife Service, Biol. Rep. 85 (1.14). Washington DC.

Environmental Protection Agency (EPA). 1997. Supplement to the environmental impact statement on the New York dredged material disposal site designation for the designation of historic area remediation site (Hars) in the New York Bight Apex. Rep. MDS/HARS SEI, U.S. EPA – Region 2, New York, NY.

Environmental Protection Agency (EPA). 1980. Ambient water quality criteria for lead. Rep. 440/5-80-057, U.S. EPA, Washington D.C.

Fields, P. W., T. S. McNevin, R. A. Harok, and J. W. Hunter 1993. A summary of selected soil constituents at Background locations in New Jersey. NJDEP, Trenton.

Franson,, J. C. 1996. Interpretation of tissue lead residues in birds other than waterfowl. Pp 265-280 in Environmental contaminants in wildlife: Interpreting tissue concentrations (W. N. Beyer, G. H. Heinz, and A. W. Redmon-Norwood, eds.). Lewis Publ. Boca Raton, Florida.

Gilfillan, S. C. 1965. Lead poisoning and the fall of Rome. J. Occup. Medicine 53: ??.

Great Lakes Environmental Center (GLEC). 1996. Summary of the Phase I Metals Sampling and analysis program for the New Jersey component of the New York/New Jersey Harbor Estuary Program. GLEC, Traverse City, Michigan.

Jaworski, J. F., J. Nriagu, P. Denny, B. T. Hart, M. R. Lasheen, V. Subramanian and M. H. Wong. 1987. Group report: lead. Pp 3-16 in Lead, mercury, lead and arsenic in the environment (T. C. Hutchinson and K. M Meema, eds.). John Wiley & Sons, Chichester, UK.

Kabata-Pendias, A. and H. Pendias. 1984. Trace elements in soils and plants. CRC Press, Inc. Boca Raton, Florida.

Ma, W. 1996. Lead in mammals. Pp 281-296 in Environmental contaminants in wildlife: Interpreting tissue concentrations (W. N. Beyer, G. H. Heinz, and A. W. Redmon-Norwood, eds.). Lewis Publ. Boca Raton, Florida.

Pain, D. J. 1995. Lead in the environment. Pp. 356-391 in Handbook of ecotoxicology (D. J. Hoffman, B. A. Rattner, G. A. Burton Jr, and J. Cairns Jr., eds.). Lewis Publ. Boca Raton, Florida.

Pain, D. J. 1996. Lead in waterfowl. Pp 251-264 in Environmental contaminants in wildlife: Interpreting tissue concentrations (W. N. Beyer, G. H. Heinz, and A. W. Redmon-Norwood, eds.). Lewis Publ. Boca Raton, Florida.

Prater, J. C. 1995. Environmental contaminant reference databook, vol. 1. Van Nostrand Reinhold, New York.

Royal Commission. 1983. Lead in the environment. CMDN 8852. Royal Commission on Environmental Pollution, ninth report, London.

Rainbow, P. S. 1996. Heavy metals in aquatic invertebrates. Pp. 405-425 in Environmental contaminants in wildlife: Interpreting tissue concentrations (W. N. Beyer, G. H. Heinz, and A. W. Redmon-Norwood, eds.). Lewis Publ. Boca Raton, Florida.

Sileo, L, and Fefer, S. I. (1987). Paint chip poisoning of Laysan Albatross at Midway Atoll. *J. Wildl. Dis.* 23, 432-437.

Thompson, D. R. 1990. Metal levels in marine vertebrates. Pp 143-182 in Heavy metals in the marine environment (R. W. Furness and P. S. Rainbow, eds.). CRC Press, Boca Raton, Florida.

Wong, D. M. W. and P. F. Sanders 1998. Characterization of ambient levels of metals and polycyclic aromatic hydrocarbons for surficial soil in the urban piedmont regions of New Jersey. Pp. 120-139 in Environmental toxicology and risk assessment: Volume 7 ASTM STP 1333 (E. E. Little, A. J. DeLonay, and B. M. Greenberg, eds.). American Society for Testing and Materials.

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Statewide Analysis of Threat

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	3-4	3	4	36-48
Marine Waters	3-4	3	4	36-48
Wetlands	3	3	4	36
Forests	2	3	3-4	18-24
Grasslands	2	3	3-4	18-24
			Total Score	144-180
			Average Score	28.8-36

HREAT = Pb

Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	M	NA	L	L	L
Passaic	M-H	M-H	M	L	L
Raritan	M-H	M-H	M	L	L
Atlantic	M	M-H	M	L	L
Lower Delaware	M	M-H	M	L	L
Region/Watershed					
Urban	H	H	M-H	NA	NA
Suburban	H	H	M	L	L
Rural	H	M-H	M	L	L

H=high, M=medium, L=low, NA = not applicable


Watershed Management Regions
Upper Delaware
Pasaic
Raritan
Lower Delaware
Atlantic Coastal

Issue: Light Pollution
Author: Dobkowski-Joy
Version: 12/28/99

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	**Light Pollution**
Stressor	Light Pollution: Lighted structures such as communications towers and tall bridges. Other lighted areas such as highways, parking lots, sky glow from cities, office buildings and residential structures were also considered.
Description of stressor	Communications towers and other tall, lighted structures cause increased avian mortality due to blind collisions with the structure as well as collisions with supporting wires following the loss of navigational cues in the light radius of the tower (usually in conditions of low cloud cover or fog). Bird mortality increases dramatically during migration seasons, and with increased tower height (www.towerkill.com). As of April 1998, 75,000 towers of greater than 200 feet exist in the United States, and construction estimates for the next ten years include plans for 100,000 additional towers (Ornithological Council Resolution, 1998). In New Jersey, there are approximately 188 towers 200-299 ft tall, 97 towers 300-499 ft tall, 14 towers 500-799 ft tall, and 4 towers taller than 800 ft (www.towerkill.com). Non-tower related lighted areas reduce feeding ranges of owls and other night feeders, and may disorient certain reptiles and amphibians (NJ Light Pollution Study Commission, 1997).
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	1. Biological Integrity/ Biodiversity Increased avian mortality due to lighted structures may effectively draw down stocks of certain bird species, however, detailed mortality data is not available. Greatly decreased bird stocks may cause changes in ecological conditions. If particular migratory birds are prone to towerkill, bird biodiversity may decrease.
Key impacts selected (critical ecological effects)	Avian mortality due to lighted communications towers.
Exposure Assessment	
Exposure routes and pathways considered	Blind collisions with tower structure. Collision with support wires or tower structure following disorientation due to light attraction.
Population(s)/ecosystem(s) exposed statewide	Unspecified bird populations in NJ (lack of mortality data prevents characterization of avian deaths into species groups).
Quantification of exposure levels statewide	See attached map of communications towers in NJ by tower height class (map from www.towerkill.com).

Issue: Light Pollution
Author: Dobkowski-Joy
Version: 12/28/99

Specific population(s) at increased risk	Large groups of migrating birds may become "stuck" at a tower, increasing the chances of collision with other birds.
Quantification of exposure levels to population(s) at increased risk	At risk populations of migratory birds face increased exposure to towerkill when conditions of fog and low cloud cover exist. Large numbers of migrants gathering at Cape May, NJ may face increased risks if more communications towers are built in the vicinity.
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	1. Observations of bird behavior near a lighted 984 ft. tower in IL on an overcast night indicated that birds concentrated around the tower when the lights were on, and dispersed upon extinguishing the tower lights (Cochran and Graber, 1958). 2. On overcast nights, birds in nocturnal migration in ND clustered around lighted towers, while on clear nights, migrating birds actively avoided tower structures (Avery, Springer and Cassel, 1976). 3. Although there are very few long-range studies of bird mortality at tall towers, anecdotal evidence and short term measurements indicate that the number of kills is greater with higher tower height (although tower location also plays into the equation- towers located on hilltops are more deadly than towers in valleys) (www.towerkill.com).
Risk Characterization	

Risk estimate(s) by population at risk	Given the lack of long-term avian mortality studies dealing with lighted towers, it is impossible to calculate an estimated mortality rate. Also, towerkill assessment is hampered by the removal of bodies by predators before an accurate count can be established.	Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure	Communication tower construction is rising sharply (with taller towers being constructed than in the past), thus contributing to increasing levels of avian mortality. It is not known whether current and expected levels of avian mortality will have lasting effects on species diversity or ecological integrity. (Score=2 Ecosystem exposed)	2

and function hardly affected 1 - No detectable exposure		
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Frequency of towerkill depends on lighted tower proliferation and weather conditions near the tower. Although tower locations can be plotted, weather conditions are more unpredictable. (Score= 3 Occasional)	3
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	Communication towers are located throughout the State of NJ, posing risks to migrating and resident bird populations. Lighted towers coinciding with migration paths pose increased risks to overflying birds.	1
	Total	6

Assessment of uncertainties in this assessment (H,M,L) and brief description	H: The risk analysis for lighted tower induced bird mortality is highly uncertain, given the lack of long and short terms bird mortality studies in New Jersey and the United States as a whole. Although significant bird mortality events have been reported in various locations, variables such as weather, tower placement and bird migration routes makes it difficult to draw conclusions about bird mortality for any specific tower height class.
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description (Data Gaps; highlight significant data needs)	(M) No long or short-term towerkill studies in New Jersey.
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description.	(–) If bird mortality jumps significantly due to increases in communications tower construction, endangered bird species may be put at greater risk of harm. In this case, this issue would become a higher priority for New Jersey.
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts	(L) Not probable.

having widespread geographic scope)	
Link to other Work Groups (e.g., socioeconomic impacts)	The placement of lighted towers is increasing with the advent of personal and cellular communication and other broadcast needs. If towers were to become restricted due to bird mortality effects, there would be potential socio-economic impacts on tower users.
Extent to which threat is currently regulated or otherwise managed	The FAA must approve any new tower above 200 ft; however, tower lighting is currently dictated by human aviation needs.
Barriers to restoration	No plans are in place to mitigate bird mortality effects of lighted towers in New Jersey.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	M
Small business industry	M
Transportation	H (Communications towers must be lighted due to FAA regulations governing tall structures)
Residential	L
Agriculture	L
Recreation	L to H (depending on how you classify the uses of communications towers- TV broadcasting, cellular phone connections, etc.)
Resource extraction	L
Government	M
Natural sources/processes	L
Orphan contaminated sites	L
Diffuse Sources	
Sediment sinks	L
Soil sinks	L

Non-local air sources incl. deposition	L
Biota sinks	L
	Table compiled on 12/28/99 by Aleksandra Dobkowski-Joy of the US EPA Region II.

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References

Avery, M, Springer, P.F., and Cassek, J.F., 1976. *The effects of a tall tower on nocturnal bird migration- A portable ceilometer study*. Auk, 93, 281-291.

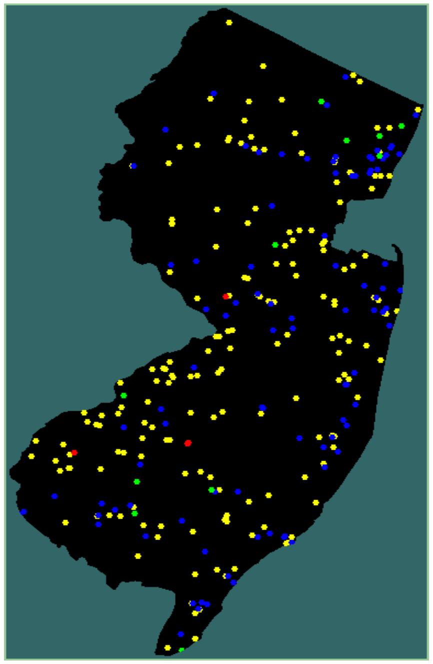
Batinsey, John. 1997. Information Sheet 121: *"New Jersey Light Pollution Study Commission Recommendations"*. Located on the International Dark-Sky Association Website: www.darksky.org/ida/ida_2/info121.html . Accessed on 12/28/99.

Cochran, William W. and Richard R. Graber, 1958. *Attraction of nocturnal migrants by lights on a television tower.* Wilson Bulletin, 70:378-380.

Ornithological Council Towerkill Resolution, 1998. (American Ornithologists' Union, Association of Field Ornithologists, Cooper Ornithological Society, and Wilson Ornithological Society). Located on the towerkill.com website. Accessed on 12/28/99.

Potter, J.K. and J.J. Murray. 1949. *Fall migration: middle Atlantic coast region*. Audubon Field Notes 3(1):8-10.

Towerkill.com. Website“devoted to serving as an information resources on the towerkill problem." Accessed on 12/28/99.



New Jersey: Tower Numbers by Height Class (Nov. 2, 1998)

Reprinted from www.towerkill.com

Key	Tower Class	Number of Towers
Yellow	200-299 feet	188
Blue	300-499 feet	97
Green	500-799 feet	14
Red	800 + feet	4

Note: The maps illustrating tower locations within each state were constructed by Harold Mills using the MatLab Mapping Toolbox from The MathWorks, Inc.

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Mercury** including inorganic (Hg^0, Hg_2^{++}, Hg^{++}) and organic (largely methylmercury [MeHg])
Description of stressor	Mercury is an element that naturally occurs in the environment, as an ore (e.g., cinnabar), in the atmosphere, and in soils and surface waters. However, mercury has been used by man for a variety of uses including as a fungicide (e.g., seed treatment), in the manufacture of chlorine and sodium hydroxide, in the pulp and paper industry as a slime control agent, in the production of plastics and electrical apparatus, and in mining and smelting operations (Eisler, 1987). Atmospheric releases (e.g., burning of fossil fuels) also result in Hg transport due to wet and dry deposition. Anthropogenic uses have greatly increased the concentrations of mercury and mercury compounds in the environment, in some cases to harmful levels. This evaluation will examine both inorganic and organic forms of mercury. Organic mercury compounds are always more toxic than inorganic mercury. MeHg is formed by bacterial methylation of inorganic mercury in aquatic and wetland systems. MeHg is very effectively accumulated by aquatic organisms. Eisler (1987) summarized several important points concerning the ecotoxicology of mercury (Hg): 1) Hg and Hg compounds have no known biological function, 2) low toxicity forms of Hg can be transformed into forms with very high toxicity, 3) MeHg can be bioconcentrated and biomagnified through food chains resulting in higher exposure to upper trophic levels, 4) Hg is a mutagen, teratogen, and carcinogen, and 5) and the anthropogenic use of Hg should be reduced, "because the difference between tolerable background levels of mercury and harmful effects in the environment is exceptionally small."
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Although EPA (1997) stated that the ecosystem effects of mercury are incompletely understood, and that no studies were found of the effects on intact ecosystems, they did identify the characteristics of ecosystems potentially at risk (from mercury releases to air). These included those systems located in areas that experience high levels of atmospheric deposition; surface waters already impacted by acid deposition; systems possessing characteristics other than low pH that result in high levels of mercury bioaccumulation in aquatic biota; and systems with species which have been subject to point source discharges of mercury (e.g., industrial outfalls) will also potentially be at risk. Impacts considered included biological integrity and biodiversity. Impacts under these categories could include acute or chronic toxicity leading to changes in populations or community structure. Tissue concentrations of mercury were also considered in relation to the impacts on the organism itself (e.g., growth or reproductive effects) and to higher trophic organisms feeding on these species. Ecosystem effects were not considered due to the paucity of data related to ecosystem health or ecosystem function.
Key impacts selected (critical ecological effects)	Key impacts used for this evaluation include biological integrity (e.g., sediment concentrations that impact benthic communities), biodiversity, and tissue concentrations.
Exposure Assessment	
Exposure routes and pathways considered	Exposure to Hg in terrestrial and aquatic ecosystems is primarily through the ingestion pathway. Exposure media include soil, surface water, sediment, and food (e.g., fish, benthic invertebrates).

Population(s)/ecosystem(s) exposed statewide	All ecosystems in the State are exposed to mercury through atmospheric deposition. Aquatic systems (freshwater and marine) are exposed through point and non-point sources, as well as cycling of mercury within the system (e.g., contaminated sediments). Other ecosystems can also be exposed through local discharges (e.g., hazardous waste sites discharging to wetlands).
Quantification of exposure levels statewide	Average concentrations of mercury (primarily inorganic) in NJ media were used to estimate statewide exposure levels. **Matrix** **Benchmark Value**
	<u>Soil</u>: Soil benchmark values in the literature range from 0.3 ppm to 5 ppm for Hg concentrations considered to be phytotoxic (i.e., toxic to vegetation; Irwin et al., 1997). A screening benchmark of 0.3 mg/kg was used for phytotoxicity based on the Oak Ridge National Laboratory's benchmark for the toxicity of Hg to plants (Efroymson et al., 1997a). No observed effect concentrations (NOECs) range from 0.12 to 10 mg/kg for terrestrial invertebrates (Van Straalen, 1993). A screening benchmark of 0.1 mg/kg was used for soil invertebrates based on the Oak Ridge National Laboratory's benchmark for the toxicity of Hg to earthworms (Efroymson et al., 1997b). Average background Hg soil concentrations in NJ range from 0.18 mg/kg (Statewide – all land uses; Fields et al., 1993), to 0.33 mg/kg (urban Piedmont regions; Wong & Sanders, 1998), to 0.5 mg/kg (urban areas; Fields et al., 1993). NJDEP (1998) The average freshwater sediment mercury concentration was 0.042 mg/kg (42 µg/kg) based on 168 samples collected between 1990 and 1997 from stations in NJ's Ambient Stream Monitoring Network. These stations are located across the State and sample freshwater stream systems. The range of median values for sediment mercury concentrations in nine Monmouth County lakes was 0.07 to 0.09 µg/g. The average mercury concentration in three other NJ lakes was 0.131 µg/g (Lake Assunpink), 0.211 µg/g (Mountain Lake) and 0.35 µg/g (Parvin Lake)(Stevenson et. al. 1995). Marine sediment concentrations vary widely depending on location. Sediments in the NY/NJ harbor area were generally higher as compared to other areas of the State. Mercury concentrations ranged from 0.076-4.81µg/g (GLEC, 1996), and Adams et al. (1998) reported an area-weighted mean concentration of 2.59 µg/g for Newark Bay area (including Arthur Kill, Kill Van Kull, Passaic River, and Hackensack River). Adams et al. (1998) estimated that 98% of the Newark Bay area sediments were anthropogenically enriched with mercury as compared to 93% for Upper NY/NJ Harbor and 71% for Lower NY/NJ Harbor. Several investigations have collected numerous sediment cores along the lower Passaic River. Average Hg concentrations in surface sediments of the river were 2.1 ppm (452 samples) with a range of 0.005 to 15 ppm (NOAA, 1999). In contrast, sediments at depth exhibited a higher average concentration (9.4 ppm) and range (0.11 ppm to 29 <u>Sediment:</u> *Freshwater benchmarks*: 0.2 mg/kg (LEL) and 2 mg/kg (SEL); *Marine benchmarks*: 0.15 mg/kg (ER-L) and 0.71 (ER-M)..6 ppm).

Sediments in the Delaware Estuary ranged in concentration from approximately 0.01 to 0.6 µg/g (Costa and Sauer, 1994; Sutton et al. 1996). Tributaries to the Delaware Estuary had sediment concentrations of <0.1-0.14 µg/g (Little Timber Creek), and up to 0.43-0.52 µg/g (Birch and Racoon Creeks) (Hochreiter and Kozinski 1985). Sutton et al. (1996) indicated that "…Urban runoff, point sources, atmospheric deposition, and ground water all contribute significant amount of mercury to the estuary. The total loading of mercury is approximately 10,000 kg/year (11 tons/year)…". The average Hg sediment concentration from 81 stations in the Delaware River and Estuary was 0.14 µg/g (NOAA, 1998).

<u>Surface Water</u>: New Jersey surface water quality criteria for mercury for freshwater are 2.1 µg/L (acute; as dissolved Hg) and 0.012 µg/L (chronic; as total recoverable Hg); and for saltwater the criteria are 1.8 µg/L (acute) and 0.025 µg/L (chronic).

For 1995-1997 surface water data, the average total mercury concentration was 0.053 µg/L (53 µg/L) based on 232 water samples from 78 freshwater stations. Most data was reported as below the detection limit and 1/2 the detection limit was used in estimating an average mercury concentration. Therefore, average mercury concentrations are probably lower. Hg was not detected in any surface water sample in 1998 (DeLuca et al., 1999). Samples for whole-water-recoverable (WWR) trace elements were collected in 1998 at approximately 40% of the 115 stations sampled with a detection limit of approximately 0.1 µg/L. Therefore, the 1995-1997 average Hg concentration may be biased high, although fewer water samples were collected in 1998.

In another study of freshwater systems using lower detection limits (0.0015 µg/L), DSRT measured surface water Hg levels of 0.0015 to 0.0198 µg/L in three NJ lakes (Stevenson et al., 1995).

No statewide average Hg concentration was readily found for NJ marine/estuarine waters. Data (GLEC, 1996) was collected for the NY/NJ Harbor area in 1995 including Raritan Bay (0.0123 µg/L maximum Hg concentration), Raritan River (0.0422 µg/L), Newark Bay (0.1267 µg/L), Hackensack River (0.2347 µg/L), and Passaic River (0.4910 µg/L). Average Hg concentrations in these waters were 0.0071 µg/L (Raritan Bay), 0.0183 µg/L (Raritan River), 0.0695 µg/L (Newark Bay), 0.0862 µg/L (Hackensack River), and 0.2499 µg/L (Passaic River).

<u>Fish Tissue</u>: Shephard (1998) recommended the use of tissue screening concentrations (TSCs) to assist in determining the risk of bioaccumulated contaminants. TSCs were defined as "whole body, wet weight tissue residues of chemicals, which if not exceeded, pose little chance of causing adverse toxicological or ecological harm to aquatic biota." These values were derived from bioconcentration factors and the ambient water quality criteria. TSCs were compared to effect tissue concentrations for over 150 chemicals including Hg based on an extensive literature review (1400 records). The TSC for Hg is 0.06 µg/g for freshwater (Shephard, 1998).

HQs were generated by comparing NJ fish tissue concentrations of Hg to the Hg TSC value. Exposure was estimated by using the data from the fish collected at 55 locations in NJ (Academy of Natural Sciences of Philadelphia, 1994).

Specific population(s) at increased risk	Piscivorous organisms/populations are at increased risk due to the biomagnification of mercury (primarily MeHg) up through the food chain. These higher trophic level organisms (e.g., bald eagles, osprey, river otter) bioaccumulate mercury from the large amounts of fish ingested. Other species (e.g., peregrine falcon) which prey on piscivorous birds are also at risk of bioaccumulating concentrations of mercury that may pose a risk. Very low concentrations of Hg in the water column can be bioaccumulated by aquatic organisms and biomagnified through the food chain (i.e., Hg concentrations increase in the organisms as you move toward the top of the food chain). Due to this effect, aquatic organisms and those species feeding on aquatic organisms are at a relatively greater risk as compared to animals that consume other food items (e.g., vegetation or terrestrial-based food items). Ecosystems adjacent to hazardous waste sites and past point sources with elevated Hg concentrations in soil, sediment and surface water are also at increased risk. Increased Hg bioaccumulation has also been observed in low pH ecosystems such as the Pine Barrens (Academy of Natural Sciences of Philadelphia, 1994).
Quantification of exposure levels to population(s) at increased risk	U.S. EPA (1997) calculated a wildlife criterion value of 50 pg/L of meHg in surface water for protection of piscivorous wildlife. Based on this value, they calculated the concentration in fish that would meet this criterion. For trophic level 3 fish this value was 0.077 µg/g , and for trophic level 4 fish this value was 0.346 µg/g. Therefore, concentrations of meHg in fish would need to be at or below these values to be protective of piscivorous birds and mammals. HQs were calculated based on a comparison of NJ fish tissue data with these values. <u>Piscivorous Birds</u>: Numerous bird species consume aquatic species including fish and benthic invertebrates. Species that eat higher trophic level fish (i.e., trophic level 3 and 4) are at the greatest risk due to biomagnification. Species of great concern in the state include bald eagle, osprey, and peregrine falcon (consumes piscivorous birds). <u>Piscivorous Mammals</u>: Two piscivorous mammals in NJ include river otter and mink. These species are considered rare in the state. <u>Piscivorous Fish</u>: Higher trophic level fish such as largemouth bass and chain pickerel are also at greater risk due to their fish diet. These fish species are located in fresh waters throughout the State. Marine species of fish such as striped bass and bluefish are migratory. Their exposure will vary depending on the time spent in waters with elevated Hg concentrations and the tissue concentrations of Hg in their prey. <u>Ecosystems adjacent to hazardous waste sites/discharges of Hg</u>: Several examples of the more severely Hg contaminated sites in NJ are provided below as estimates of Hg exposure to ecological receptors. Pierson's Creek located in Newark has been grossly contaminated with a number of contaminants including Hg from the Troy Chemical site and other sites in the area. This man-made waterway discharges to Newark Bay just south of the mouth of the Passaic River. Sediment and surface water of the creek have been contaminated with Hg, with maximum concentrations of 607,000 ppm and 886 ppb, respectively. A concentration of 83,200 ppm of Hg was detected in the sediment of an adjacent tributary; and a maximum of 47 ppm of Hg was found in ground water at the site.

	The Pompton Lakes Works (PLW) site is located in Passaic County and was operated by DuPont between 1908 and 1994 (Exponent, 1999) for the manufacture of explosives. Acid Brook flows through the facility and discharges to Pompton Lake where it has formed a delta (i.e., Acid Brook delta). Soil contamination was detected in both on-site and off-site areas affecting both commercial and residential properties. Mercury contamination from on-site soils ranged from non-detect to free product. Acid Brook sediments contained elevated levels of Hg. Due to the contamination found, DuPont conducted remediation of on-site and off-site soils, as well as remediation of sections of Acid Brook sediments. Sediments in the delta have maximum levels of Hg of 1,450 ppm. Draft results indicate that Hg and meHg concentrations were higher at the delta locations as compared to an in-lake reference station for algal mats, phytoplankton, zooplankton, and benthic invertebrates. In addition, fish tissue meHg concentrations were higher in all 7 species of fish captured at the delta as compared to the reference area. The data suggests that the delta contamination is contributing to bioaccumulation of Hg within the food chain of Pompton Lake. Berry's Creek, located in the Hackensack Meadowlands, is one of the most heavily contaminated Hg sites in New Jersey. Sediment Hg concentrations up to 11,100 ppm have been found in Berry's Creek. Surface soil concentrations up to 13,800 ppm and subsurface soil concentrations of up to 123,000 ppm have been detected on the adjacent Hg processing plant site (Ventron/Velsicol site). Estimates of the amount of Hg contamination beneath the Ventron/Velsicol site have ranged from 30 tons to 289 tons (Lipsky et al., 1980). In addition, an estimate of average Hg concentrations around inland waters was conducted using sites that had undergone an ecological risk evaluation under NJDEP's SRP. Surface water concentrations of Hg from 7 sites ranged from non-detectable to 3 µg/L. Sediment concentrations at 10 sites ranged from non-detectable to 32 mg/kg. .
	A qualitative assessment of exposure is necessary for hazardous waste sites due to the wide range in Hg concentrations observed, and since normally the highest concentrations are remediated. However, remediation of sediments at the above mentioned sites are either planned but not initiated or not planned for the near future. Therefore, these types of sites will continue to pose potential risk to aquatic ecosystems. <u>Low pH Systems:</u> The NJ Pinelands (or Pine Barrens) is the primary example of a low pH ecosystem in New Jersey. Low pH systems generally promote higher concentrations, mobility, and methylation of mercury (USGS, 1996). Alkalinity, specific conductance, pH, and the concentration of calcium in water have been shown to be inversely correlated with concentrations of mercury in fish (Wiener and Stokes, 1990). Fish in acidic lakes have been shown to have higher tissue burdens of Hg as compared to nearby lakes with higher pH (EPA, 1997). Increased accumulation of Hg in low pH lakes may be due to increased microbial production of MeHg and/or biogeochemical processes (EPA, 1997); although dissolved organic carbon may be a better predictor of fish tissue concentrations than pH is some systems (EPA, 1997). Exposure for this system was estimated from fish tissue concentrations. Mercury concentrations in fish were greater than 1.0 and 0.5 µg/g most frequently in very large lakes, the Pine Barrens, and in some sites adjacent to the Pine Barrens (Academy of Natural Sciences of Philadelphia, 1994). High Hg concentrations were most frequent in chain pickerel from the Pine Barrens (pH 4-5) and in sites marginal to the Pine Barrens (pH 5-6) (Academy of Natural Sciences of Philadelphia, 1994). All chain pickerel from the Pine Barrens had concentrations greater than 0.5 µg/g and 70% were greater than 1.0 µg/g (Academy of Natural Sciences of Philadelphia, 1994)
Dose/Impact-Response Assessment	

Quantitative impact-assessment employed	Statewide average concentrations of mercury (where available) were compared to screening benchmarks to assess the risk to organisms living in NJ's ecosystems. Benchmarks for soil, sediment, surface water, and fish tissue were compared to available data on mercury concentrations in NJ for these matrices. The hazard quotient (HQ) method was used to conduct a screening level risk assessment where: $HQ = \frac{\text{Estimated Environmental Concentration}}{\text{Benchmark Concentration}}$ The HQ was used as a measure of potential risk for the various ecosystems. This assumed that concentrations of the contaminant in the various environmental matrices (e.g., soil, water, sediment) were representative of the exposure to biota in those systems. HQ values <1 indicate Hg concentrations are at a level where adverse effects are not expected and little or no potential risk; values >1 indicate that Hg concentrations are at a level where adverse effects may potentially occur, and there is potential risk to ecological receptors.	
Risk Characterization		
Risk estimate(s) by population at risk	**1) STATEWIDE**: Soil: The soil benchmark for Hg phytotoxicity was used to calculate HQs. HQs were 0.6 for Statewide, 1.1(urban Piedmont), and 1.7 in urban areas. For terrestrial invertebrates the HQ values were1.8 for statewide, 3.3 for urban Piedmont, and 5.0 for urban. In contrast to aquatic systems, bioaccumulation in terrestrial ecosystems is relatively low (Wren et al., 1995). Sediment: This data results in HQs of 0.02 (for SEL) to 0.21 (for LEL) for freshwater stream sediments. For lakes the HQs ranged from 0.35 to 1.75 (LEL), and from 0.04 to 0.18 (SEL). For marine/estuarine sediments the HQs range from <0.1 to 63 (ER-L) and <0.1 to 13 (ER-M). Freshwater: 1995-1997 Data: HQ = 0.02 (acute) and 4.42 (chronic).	Score

DSRT Data: HQs = 0.001 to 0.009 (acute), and 0.12 to 1.65 (chronic).

Marine/Estuarine Water: HQs for the average Hg concentration in the waterbodies detailed previously ranged from <0.01 to 0.14 for acute criteria, and from 0.28 to 10.0 for chronic criteria. HQs for the listed maximum Hg concentrations range from 0.01 to 0.27 (acute), and 0.49 to 19.6 (chronic).

Fish Tissue: HQs for the range in tissue concentrations by species (# of samples) was:

Largemouth Bass (146): 0.8 to 149
Chain Pickerel (62): 1.5 to 47
Smallmouth Bass (21): 1.3 to 8.5
Channel Catfish (12): 1.2 to 12
Brown Bullhead (15): 0.3 to 7.8

2) PISCIVOROUS SPECIES:
A comparison of the EPA (1997) estimates for Hg tissue levels in trophic level 3 and 4 fish and a the 54 New Jersey waterbodies sampled in 1992-93 for NJDEP (Academy of Natural Sciences of Philadelphia, 1994) indicates trophic level 4 (TL4) fish tissue concentrations exceed the level for protection of piscivorous wildlife. The data indicates that largemouth bass in 28% and chain pickerel in 41% of the waterbodies examined exceeded a Hg tissue concentration of 0.54 µg/g.
HQs ranged from 0.14 to 26 (largemouth bass, TL4), 0.26 to 8.2 (chain pickerel, TL4), 0.2 to 2.1 (channel catfish, TL4), and 0.26 to 6.1 (brown bullhead, TL3). Therefore risks to piscivorous species would be rated **HIGH**.

3) HAZARDOUS WASTE SITES: The risk to ecosystems in NJ was estimated to range from **LOW to MODERATE** for terrestrial-based ecosystems, to **MODERATE to HIGH** for aquatic-based systems. This moderate to high rating is based on the more severe impacts of Hg on aquatic systems (as compared to terrestrial systems), the bioaccumulation and biomagnification of Hg in these systems, and the concentrations of Hg observed in sediments adjacent to and downstream of sites that discharged Hg.

4) LOW pH SYSTEMS: Based on the fish data collected in the Pine Barrens, particularly the Hg tissue concentrations in chain pickerel, it

	appears that fish in low pH systems bioaccumulate greater amounts of Hg as compared to higher pH systems. In addition, the body burdens of Hg in fish species would present a greater risk to piscivorous wildlife. Therefore, aquatic ecosystems within low pH systems (i.e., Pine Barrens) would be rated as **HIGH** risk to Hg.	
Assessment of severity/irreversibility	The following scale was used when assigning a score to the generated HQs: <u>HQ</u> <u>Score</u> <1 1 1-5 2 6-10 3 4 25+ 5 On a Statewide basis, the severity of effects to all ecosystems is rated a 3.5 based on the average Hazard quotient and estimated effects to piscivorous species.	3.5
Assessment of frequency of effect(s): 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	On a Statewide basis, the frequency of effects is often and continuing (4) for aquatic systems, and is rated as occasional (3) for terrestrial systems.	3-4
Size of population(s) and/or extent of the State/habitat affected (impacted): 5- >50% of the State/population impacted	It is estimated that between 10 and 25 % of the State is impacted by mercury, with aquatic systems rated a "5" and accounting for the majority of impacts.	3.5

4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted		
	Total	36.8-49
Assessment of uncertainties in this assessment (H,M,L) and brief description	There is moderate uncertainty with this assessment. There is limited data available on surface water, sediment, and fish tissue concentrations. However, these data do not cover all habitats in the State. In addition, some of the data utilized had detection limits greater than screening criteria or surface water quality criteria (e.g., chronic surface water criteria). Therefore, the risk to aquatic life may be underestimated.	
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description (Data Gaps; highlight significant data needs)	Currently there is no comprehensive or regular monitoring of mercury levels in biological tissues in the State. Ecosystem-level effects are poorly understood, and additional research is needed to better characterize the long-term and chronic effects of mercury deposition/discharge to the environment. Additional monitoring of the State's waters using lower detection limits are needed to assess concentrations of Hg and their impacts on aquatic life and wildlife. Additional data may moderately change this risk estimate. More concise estimates of risk will be possible as more data becomes available on mercury levels in the State, and as national/international research directed at ecosystem-level effects is completed. Chronic level effects may be more apparent as the effects of mercury in the environment are better understood. Alternatively, additional data could show that ecosystem processes effectively mitigate the impacts of mercury on all but the most contaminated sites, with the exception of impacts to higher trophic level (piscivorous) animals.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description.	The potential for significant future change in the underlying risk from mercury is rated (0). Mercury is a conservative element (i.e., does not degrade), and continued discharge could potentially result in cumulative effects on ecological receptors, especially animals at the top of the food chain. Loadings from some sources of mercury have been reduced which would indicate an improvement, however, other sources continue to discharge (e.g., atmospheric deposition), and impacts on higher trophic level animals may increase in the future.	
Potential for catastrophic impacts (H,M,L) and brief description	The potential for catastrophic impacts to NJ's ecosystems and associated biota is considered to be low based on current release rates, the fate of mercury compounds, and current knowledge of the severe adverse effects of Hg.	
Link to other Work Groups (e.g., socioeconomic impacts)	Potential socioeconomic impacts of mercury contamination include the economic costs of remediating hazardous waste sites and contaminated sediments to protect ecosystems; Loss or reduction in threatened and endangered species (e.g., bald eagle, peregrine falcon, osprey); habitat damage due to Hg concentrations in sediment.	

Extent to which threat is currently regulated or otherwise managed	NJDEP's Site Remediation Program (SRP) regulates Hg in the form of administrating or conducting the cleanup of Hg contaminated sites to levels that are safe to human health and the environment. Much of this remediation involves contaminated soils; contaminated sediments have also been remediated at smaller scale sites. Contaminated sediments at larger scale sites (e.g., Passaic River, Berry's Creek) are regulated by State and/or Federal agencies, depending on the water body and action (e.g., dredging, remediation). Actions to date have not adequately addressed the risk of Hg contamination at these sites.
Barriers to restoration	Continued atmospheric release and subsequent deposition. Technology and costs associated with remediating contaminated sediments.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	The primary sources to NJ ecosystems appear to be emissions to the atmosphere from energy producers, and historical industrial discharges (as evidenced by sediment concentrations). Numerous low-concentration sources (e.g., sewerage outfalls, and industrial outfalls) probably also add Hg to NJ's aquatic systems. The combination of atmospheric deposition, point sources, and non-point runoff results in contamination of NJ's aquatic ecosystems.
NJ Primary Sources	
Large business/industry	H: A large source of Hg emissions to the atmospheric is energy and heat production (e.g., coal-fired utilities, commercial and industrial boilers). This energy production is utilized by many sources in the State as indicated by *EP; product use and waste management; discharges to water
Small business/industry	H: *EP; product use and waste management; discharges to water
Transportation	L: *EP; Hg in gasoline and other fuels will be emitted upon combustion.
Residential	M: *EP; use of Hg-containing products and subsequent disposal including discharges to water; releases from cultural and ceremonial uses..
Agriculture	L: Sludge application; Inorganic mercurial pesticides were used in NJ from possible as early as 1890 until the 1950's. Organic mercurial pesticides were used from the 1940's until 1972 when their use on food crops was ceased. The only recent registered use in NJ is for mercurous chloride for snow mold on golf courses (NJDEP et al., 1994); this is no longer a registered use (i.e., discontinued).
Recreation	L
Resource extraction	L
Government	M: *EP, municipal waste combustion, landfills and sludge incineration
Natural sources/processes	M: Oceans, vegetation, volcanoes, rocks, soils, wildfires. Natural emissions of Hg can be transported globally.
Orphan contaminated sites	M; discharges to water and air
Diffuse Sources	
Sediment	H: Historical industrial activity including air and water discharges have resulted in elevated concentrations of Hg in sediments in the urban areas of the State. These sediments now are a source of Hg to aquatic ecosystems and piscivorous wildlife.
Soil	L:
Non-local air sources incl. Deposition	H: Emissions from other non-local energy producers (*EP) have resulted in dry and wet deposition of Hg in NJ.

Biota	M: Bioaccumulation and biomagnification of Hg (from water, sediment, and food) up through the food chain can be a source of Hg to higher feeding (trophic levels) of fish and wildlife (and humans).

Summary Statement: Mercury is a natural element that exists in both inorganic and organic (e.g., methylmercury) forms. Organic mercury compounds are always more toxic than inorganic mercury. Man's use of mercury has contaminated the environment through direct (e.g., point sources) and indirect (e.g., atmospheric deposition) pathways. Mercury compounds have no known biological function; MeHg can be bioconcentrated and biomagnified through food chains; and Hg is a mutagen, teratogen, and a carcinogen. The highest risk of Hg (primarily MeHg) is to piscivorous (fish-eating) species.

Piscivorous organisms/populations are at increased risk due to the biomagnification of mercury (primarily MeHg) up through the food chain. These higher trophic level organisms (e.g., bald eagles, osprey, river otter) bioaccumulate mercury from the large amounts of fish ingested. Other species (e.g., peregrine falcon) which prey on piscivorous birds are also at risk of bioaccumulating concentrations of mercury that may pose a risk. Very low concentrations of Hg in the water column can be bioaccumulated by aquatic organisms and biomagnified through the food chain (i.e., Hg concentrations increase in the organisms as you move toward the top of the food chain). Due to this effect, aquatic organisms and those species feeding on aquatic organisms are at a relatively greater risk as compared to animals that consume other food items (e.g., vegetation or terrestrial-based food items). Increased Hg bioaccumulation has also been observed in low pH ecosystems such as the Pine Barrens (Academy of Natural Sciences of Philadelphia, 1994). Therefore, most terrestrial ecosystems would be considered at low risk; whereas aquatic systems would be considered at moderate to high risk to MeHg depending on location. Those freshwater and marine systems located adjacent to urban/industrial and/or Hg hazardous waste sites would be considered to be at the greatest risk.

Rating of the Severity/Irreversibility effects of mercury ranges from 2 (indicating very few effects in terrestrial systems) to 3-4 (indicating effects between adverse and serious in marine waters). Frequency of the threat is considered to be "often and continuing" due to atmospheric deposition across the entire state, and continuation of sources of low-concentration point discharges. Magnitude is rated a "5" for aquatic ecosystems, since most or all aquatic habitats in the state are potentially affected by mercury deposition, and a "2" for terrestrial systems due to the minimal impacts reported on these ecosystems.

Issue: Mercury
Author: Buchanan
Version: 04/14/00

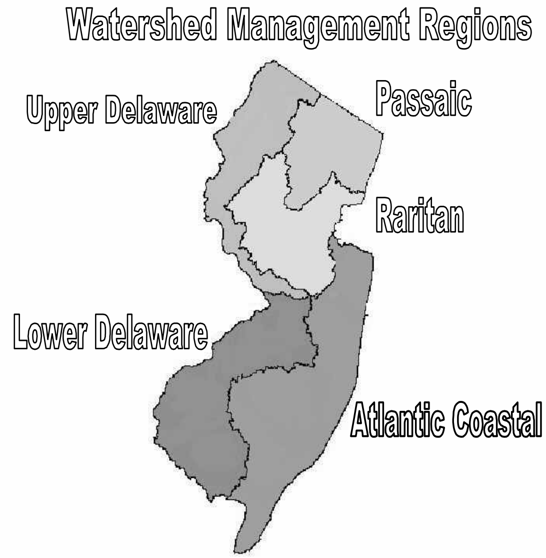
Statewide Analysis of Threat Threat = Mercury

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	3	4	5	60
Marine Waters	3-4	4	5	60-80
Wetlands	2-3	4	5	40-60
Forests	2	3	2	12
Grasslands	2	3	2	12
			Total Score	184-224
			Average Score (Total ÷ 5)	36.8-44.8

Risk by Watershed Management Region

THREAT = Mercury	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	M	NA	L	L	L
Passaic	M-H	H	M-H	L	L
Raritan	M-H	H	M-H	L	L
Atlantic	M-H	L	L-M	L	L
Lower Delaware	M	M	L-M	L	L
Region/Watershed (secondary)					
Urban	H	H	M-H	NA	NA
Suburban	L-M	L-M	L-M	L	L
Rural	M	L	L	L	L

H=high, M=medium, L=low, NA = not applicable



References:

Academy of Natural Sciences of Philadelphia. (1994). Preliminary assessment of total mercury concentrations in fishes from rivers, lakes, and reservoirs of New Jersey. Report No. 93-15F. Prepared for NJDEP.

Adams, D.A., J.S. O'Connor, and S. B. Weisberg. (1998). Sediment Quality of the NY/NJ Harbor System. Final Report. EPA/902-R-98-001. Regional Environmental Monitoring and Assessment Program, USEPA.

Costa, H.J. and T.C. Sauer. 1994. Distributions of chemical contaminants and acute toxicity in Delaware Estuary sediments. Final Report, DELEP #94-08. For Delaware Estuary Program, U.S. Environmental Protection Agency, by Arthur D. Little, Inc., Cambridge, MA. 89 pp. and appendices.

DeLuca, M.J., J.H. Oden, K.M. Romanok, and M.L. Riskin. (1999). Water Resources Data, New Jersey, Water Year 1998. Volume 3. Water-Quality Data, Water-Data Report NJ-98-3. U.S. Geological Survey, 450 pp.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. (1997a). Toxicological benchmarks for contaminants of potential concern for effects on terrestrial plants: 1997 Revision. Prepared for U.S. Department of Energy, Oak Ridge National Laboratory by Lockheed Martin Energy Systems, Inc. 123 p.

Efroymson, R.A., M.E. Will, and G.W. Suter II. (1997b). Toxicological benchmarks for contaminants of potential concern for effects on soil and litter invertebrates and heterotrophic process: 1997 Revision. Prepared for U.S. Department of Energy, Oak Ridge National Laboratory by Lockheed Martin Energy Systems, Inc. 151 p.

Eisler, R. (1987). Mercury Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report 85 (1.10), Contaminant Hazard Reviews, Report No. 10. 90 pp.

Fields, T. W., McNevin, T.F., Harkov, R.A., and Hunter, J.V. (1993). A summary of selected soil constituents and contaminants at background locations in New Jersey. New Jersey Department of Environmental Protection.

Great Lakes Environmental Center (GLEC). (1996). Summary of the phase I metals sampling and analysis program for the New Jersey component of the New York/New Jersey Harbor Estuary Program. Prepared for the NJ Harbor Dischargers Group.

Hochreiter, J.J., Jr. and J. Kozinski. 1985. Quality of water and bed material in streams of Logan Township, Gloucester County, New Jersey, 1984. U.S. Geological Survey Water Resources Investigations Report 85-4300.

Irwin, R. J., M. VanMouwerik, L. Stevens, M.D. Seese, and W. Basham. (1997). Environmental Contaminants Encyclopedia. Mercury Entry. National Park Service, Water Resources Division, Fort Collins, Colorado.

Jarvinen, A.W. and Ankley, G.T. (1999). Linkage of effects to tissue residues: development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. Pensacola FL: Society of Environmental Toxicology and Chemistry (SETAC). 364 pp.

Lipsky, D., R. J. Reed, and R. Harkov. (1980). Mercury Levels in Berry's Creek. Office of Cancer and Toxic Substances Research. NJDEP. 76 pp.

National Oceanic and Atmospheric Administration (NOAA). (undated). Query Manager 1.4 with MARPLOT™, Newark Bay CD ROM database. Hazardous Materials Response and Assessment Division. Received October 1999.

NJDEP, NJ Department of Health, and NJ Department of Agriculture. (1994). Mercury Contamination in New Jersey Freshwater Fish, Report of the Toxics in Biota Committee. 88 pp.

NJDEP. (1998). Guidance for Sediment Quality Evaluations. Site Remediation Program, NJDEP. 28 pp.

NOAA, 1998. Draft data for the Mid-Atlantic Integrated Assessment (MAIA).

Shephard, B.K. (1998). Quantification of ecological risks to aquatic biota from bioaccumulated chemicals. Pp. 2-31 to 2-52, IN: National Sediment Bioaccumulation Conference Proceedings. September 11-13, 1996, Bethesda, Maryland. EPA 823-R-98-002. Office of Water.

Stevenson, E., R. England, and B. Ruppel. (1995). A pilot study to assess trace levels of mercury in New Jersey lakes and precipitation. Research Project Report. NJDEP, Division of Science and Research, Trenton, NJ, 22 pp.

Sutton, C.C, J.C. O'Herron, II and R.T. Zappalorti. 1996. The Scientific Characterization of the Delaware Estuary. The Delaware Estuary Program (DRBC Project No. 321; HA File No. 93.21). 200 ppg. and appendices

U.S. Geological Survey. (1996). Summary document for the USGS Workshop on Mercury Cycling in the Environment, Golden, Colorado, July 7-9, 1996. USGS Water Resources Division. Office of Water Quality, Reston , VA, October 1996. 10 pp.

Van Straalen. (1993). Soil and sediment quality criteria derived from invertebrate toxicity data. In: Ecotoxicity of metals in invertebrates. R. Dallinger and P.S. Rainbow, Eds. Lewis Publishers, Boca Raton, FL.

Wiener, J.G. and P.M. Stokes. (1990). Enhanced bioaccumulation of mercury, cadmium, and lead in low-alkalinity waters; an emerging regional environmental problem. Envir. Tox. Chem. 9: 821-823.

Wong, D. M. W. and Sanders, P.F. (1998). Characterization of ambient levels of metals and polycyclic aromatic hydrocarbons for surficial soil in the urban Piedmont region of New Jersey. Environmental Toxicology and Risk Assessment: Seventh Volume, ASTM STP 1333, E.E. Little, A.J. DeLonay, and B.M. Greenberg, Eds., American Society for Testing and Materials, pp. 120-139.

Wren, C.D., Harris, S., and Harttrup, N. (1995). Ecotoxicology of mercury and cadmium. In: Handbook of Ecotoxicology. D.J. Hoffman, B.A. Rattner, G.A. Burton, Jr., and J. Cairns, Jr. Lewis Publishers.

Issue: MSX Parasite in Oysters
Author: Mary Downes-Gastrich
Version: 05/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**MSX Parasite in Oysters** *Haplosporidium nelsoni* (MSX=multinucleated sphere X) of *Crassostrea virginica* (American oyster)
Description of stressor	A spore-forming protozoan (Phylum Ascetospora, class Stellatoporea, order Balanosporida, and family Haplosporidiidae) causing the MSX disease or "Delaware Bay disease". It is prevalent along the mid-Atlantic coast of the US but reported from Maine to Florida. The predominant form of the organism in the oyster is a multinucleated plasmodium (Ford & Tripp 1996). Temperature and salinity are two major factors: *H. nelsoni* is active at temperature above 10 ^{0}C and intolerant of salinities below 10 ppt. (Ford and Tripp 1996) and restricted to salinities over 15 ppt (Fisheries and Oceans, Canada 1999); sporulation of MSX is sporadic in adult *C. virginica* but prevalent in juvenile oysters; when present, it occurs in summer and early fall. The MSX life cycle is unknown. DNA analysis indicates that *H. nelsoni* was introduced to the east coast of the U.S. to the Pacific Ocean, where it is a parasite of C. gigas (Burreson et al., 2000). The method of introduction is unknown.
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Biological Integrity: Causes high mortality *in Crassostrea virginica* (Ford & Tripp 1996) at 20 ppt (Fisheries and Oceans, Canada 1999); rapid death in highly susceptible oysters (Ford and Tripp 1996). Massive oyster mortalities in lower Delaware Bay estuary occurred in 1957. In the early and mid-1960s, *H. nelsoni*, was found in NJ (Haskin et al.) 1966; Haskin and Andrews 1988); Effects of disease on oyster metabolism: Growth: Susceptible oysters infected with *H. nelsoni* stop growing 2-3 weeks before they die (Andrews 1966). While death of highly susceptible oysters is rapid (Ford et al 1988), more tolerant oysters showed reductions of condition index (dry weight of soft tissue/shell cavity volume X 100) correlated with infection intensity in Delaware Bay in 1985 and survived for longer periods (Newell 1985, Barber et al.) 1988; Ford et al.) 1988); Physiological functions:
	Clearance (feeding) rates of infected oysters were less than half those of uninfected oysters but oxygen consumption was not related to infection (Newell 1985);

	Biochemical composition: Glycogen, lipid, and protein were all reduced in oysters with *H. nelsoni* infections but glycogen was depleted to a greater extent than either of the other components (Barber et al.) 1988); Reproduction: Gonadal development can be severely impaired by H. nelsonii infections (Ford & Figueras 1988); 5) Cause of death: not completely understood. Highly susceptible oysters usually appear in good condition when they die (they are fat and storage cells of the visceral mass are large and intact) (Ford & Tripp, 1996). Pathology: mantle recession, pale "digestive gland", emaciation (Farley 1968; Ford & Tripp 1996).
Key impacts selected (critical ecological effects)	Oyster mortality Metabolic effects Gross and microscopic pathology
Exposure Assessment	
Exposure routes and pathways considered	Mode of transmission: unknown (Ford & Tripp 1996); transmission directly between oysters has not been observed. A requirement for an intermediate host is hypothesized (Fisheries and Oceans, Canada 1999; Ford & Tripp 1996); Portal of Entry: Earliest infections are found in the gill and palp epithelia of oysters (Ford & Tripp 1996; Ford and Figueras 1988) and in rare instances, through the gonoducts.
Population(s)/ecosystem(s) exposed statewide	Prevalence Levels and Mortality Rates: Infection levels and consequent mortality rates vary seasonally, annually, regionally, and according to previous selective mortality (reported in Ford & Tripp 1996). Populations of the American oyster, *C. virginica*, are found in the Delaware Estuary watershed (WMA #16,17,18) and in the Atlantic coastal bays. The distribution of MSX is not associated with the presence of pollutants (Ford & Tripp 1996). If pollution association were a factor, it would have been documented by now (Ford, pers comm.).
Quantification of exposure levels statewide	*H. nelsoni* infective pressure is independent of oyster density and is fairly uniform over a large area within the high salinity portion of affected estuaries (Ford & Tripp 1996). With favorable salinities, it can spread rapidly over large distances (Ford & Tripp, 1996, Andrews and Wood, 1967; Andrews 1979; Haskin and Ford 1982); most fluctuations in *H. nelsoni* prevalence in Chesapeake Bay were correlated with river flow and salinity changes (Andrews and Frierman 1974; Farley 1975; Ford and Tripp 1996); factors other than the two major factors of temperature and salinity affect the distribution and abundance of *H. nelsoni* (Ford and Tripp 1996).
Specific population(s) at increased risk	*Crassostrea virginica* (American oyster)
Quantification of exposure levels to population(s) at increased risk	Epizootic/enzootic periodicity: Fluctuations in levels of *H. nelsoni* in *C. virginica* on a yearly basis were noted in Delaware Bay when infection rates were reduced for several years after the original infection in the late 1950s (Ford & Haskin 1982). Three more periods of low activity of 1-2 yrs duration, interspersed with 5-6 yrs of high infection, have been documented but not correlated with salinity. However, each low-activity period was preceded by an extremely cold winter (Ford & Tripp 1996; Ford and Haskin 1982). Since about

	1990, MSX disease levels in the Delaware Bay have been very low, despite a lack of very cold winters. Evidence suggests that the native oysters have become highly resistant (see below)(Ford, pers. comm.). Environmental Influences: A study showed three critical temperature ranges for the eastern oyster-*H. nelsoni* association: below 5#C, both organisms are inactive; between 5^0 and 20#C, *H. nelsoni* proliferates more rapidly than the oysters can control it; above 20 ^{0} C, resistant oysters can overcome the parasite but susceptible oysters are killed (Ford & Tripp 1996). Low salinity is a critical influence in reducing infections. *H. nelsoni* disappeared from oysters on James River (Chesapeake Estuary) seed beds when they were exposed to salinities of 10 ppt or less for about 2 weeks during Spring freshets (Ford & Tripp 1996). This has also been demonstrated experimentally (Ford, pers. comm.).	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed	The minimum infective dose is not known because *H. nelsoni* has not been transmitted under controlled conditions but a relationship between dosage and subsequent infection levels is suspected (Ford & Haskin 1982; Haskin and Andrews 1988). The infective pressure of *H. nelsoni*, unlike Dermo, is independent of oyster density and it's fairly uniform over a large area within the high salinity portion of affected estuaries (Ford & Tripp 1996).	
Risk Characterization		
Risk estimate(s) by population at risk (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score

Assessment of severity/irreversibility Risk Score 5 – Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	Prolonged drought conditions (up to 5 yrs), with elevated salinities, can result in movement of *H. nelsoni*, upward into the Delaware Estuary as it did in the mid-1960s into regions that had formerly been free of parasites (Farley 1975; Ford & Tripp 1996; Haskin & Ford 1982). With the return of normal precipitation levels in the late 1960s and early 1970s, *H. nelsoni* returned to former locations downward in the Estuary (Ford & Tripp 1996). The MSX parasite again moved up the Delaware Estuary in the early and mid-1980s, where it caused major mortalities (Ford, pers. comm.). Natural Resistance: Since about 1990s, the prevalence and severity of MSX has been very low in the Delaware Bay, although the presence of infective particles has been documented throughout the Bay using molecular detection methods (Ford, pers. comm.). Susceptible oysters experimentally exposed in the Delaware Bay waters continue to became heavily infected. It is hypothesized that the heavy mortalities of seed oysters in the mid-1980s substantially increased the moderate levels of resistance to MSX disease that developed in the native population after the 1957-59 epizootic (Ford, pers. comm.). The Delaware Bay population is now quite resistant to the development of MSX disease (Ford, pers. comm.).	3

Issue: MSX Parasite in Oysters
Author: Mary Downes-Gastrich
Version: 05/00

Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Eastern oyster, *Crassostrea virginica* natural beds or reefs (seed beds) cover much of the upper Delaware Bay (Delaware Bay in WMA #17, #16) and produce the seed oysters essential for the oyster industry. In the Delaware Estuary, oysters grow from the Delaware Bay entrance to Bombay Hook on the Delaware side and to just below Artificial Island on the New Jersey side (a salinity range of about 30 ppt to 5 ppt). The oyster-growing grounds are separated into upper bay seed beds and lower bay leased grounds; while oyster harvests vary year to year, the oyster population is severely depressed due to MSX and Dermo (another disease of oysters) (Ford et al.) 1996).	4
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted		2
	Total	24

Assessment of uncertainties in this assessment (H,M,L) and brief description	L-M =Low because the prevalence of MSX has been well documented in NJ. However, because of the unknown variability of environmental conditions that could last over long periods (e.g., droughts over 5 yrs can increase salinities, which can increase disease). Because the life cycle of the parasite is not known, there could be some medium level of uncertainty.
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and a brief description	(Low) MSX has been well documented and there has been substantial research on the organism. Determination of an infective dose of *H. nelsoni* through controlled transmission of the organism and experimental verification between dosage and subsequent infection levels (Ford & Tripp 1996); establish whether there is an intermediate host (Ford & Tripp 1996).
Potential for future change in the underlying risk from this stressor (+++, ++, +,0,-,=,≡) and brief description	(0 to +) if appropriate management actions are taken (e.g. maintain the salinity regimes in the upper Delaware estuary so that there are low salinities that protect the young oysters from predation and disease organisms (Ford et al.) 1996) and management actions that avoid projects resulting in permanent water withdrawal from the estuary that reduce seasonal variation of fresh water inputs or introduce more salt in the upper Estuary (Ford et al.) 1996).
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	M=Medium because oysters that survived the 1957-59 epizootic produced offspring more resistant; high recruitment, a shortened planting cycling the lower bay and improved disease resistance fostered a revival of the industry over a 15-year periods in 1970s and 1980s. A drought in the mid-1980s brought a resurgence of MSX where salinities were elevated. In 1990, Dermo disease negatively affected oysters.
Link to other Work Groups (e.g., socioeconomic impacts)	Economic impacts of reduced oyster populations in New Jersey.
Extent to which threat is currently regulated or otherwise managed	Specifically, MSX is not regulated. NJDEP's National Shellfish Sanitation Program surveys shellfish growing in waters in the state and classifies them according to the presence and abundance of coliform bacteria and significant sources of potential

	contamination. Water data are combined with land use, water hydrography and pollution source information to classify the NJ's shellfish growing waters for harvesting. Studies on Control Measures: Control measures that work for dermo disease do not generally work for MSX. The best control for MSX is to use resistant strains of oysters produced in hatcheries using aquaculture techniques such as those employed at Bivalve, NJ. When wild seed is used, oysters should be kept in disease-free areas as long as possible and if moved to areas where the parasite is prevalent, the move should avoid the early summer infection period - and oysters should be harvested the same fall or following spring (Ford and Haskin 1988). Low salinity immersion to rid oysters of the parasite is potentially useful but more study is needed on this (Ford & Tripp 1996).
Barriers to restoration	Management at the local level needs to continue to be coordinated at the state level with respect to managing water withdrawals, controlling river flow through dam construction or channel dredging.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	No sources known
Large business/industry	
Small business industry	
Transportation	
Residential	
Agriculture	
Recreation	
Resource extraction	
Government	
Natural sources/processes	
Orphan contaminated sites	
Diffuse Sources	
Sediment sinks	
Soil sinks	

Non-local air sources incl. deposition	
Biota sinks	

Issue: MSX Parasite in Oysters
Author: Mary Downes-Gastrich
Version: 05/00

REFERENCES

Andrews, J.D. 1966. Oyster mortality studies in Virginia. V. Epizootiology of MSX, a protistan parasite of oysters. Ecology 47:19-31.

Andrews, J.D. 1979. Oyster diseases in Chesapeake Bay. Mar. Fish. Rev.
41(1-2):45-53.

Andrews, J.D. and M. Frierman. 1974. Epizootiology of *Minchinia costalis* in susceptible oysters in seaside bays of Virginia's Eastern shore, 1959-1976. J. Invert. Pathol. 32:124-138.

Andrews, J.D. and J.L. Wood. 1967. Oyster mortality studies in Virginia. VI. History and distribution of *Minchinia nelsoni,* a pathogen of oysters, in Virginia. Chesapeake Sci. 8:1-13.

Barber, B.J., S.E. Ford and H.H. Haskin. 1988. Effects of the parasite MSX (*Haplosporidium nelsoni)* on oyster (*Crassostrea virginica)* energy metabolism. I. Condition index and relative fecundity. J. Shellfish Res. 7:25-31.

Burreson, E.M., Stokes, N.A. and Friedman, C.S. 2000. Increased virulence in an introduced pathogen: *Haplosporidium nelsoni* (MSX) in the eastern oyster *Crassostrea virginica.* J. Aqat. An. Health, 12:1-8.

Farley, C.A. 1968. *Minchinia nelsoni (*Haplosporida) diseases syndrome in the American oyster (*Crassostrea virginica).* J. Protozool. 15:585-599.

Farley, C.A. 1975. Epizootic and enzootic aspects of *Minchinia nelsoni* (Haplosporida) disease in Maryland oysters. J. Protozool. 22:418-427.

Fisheries and Oceans Canada. 1999. *Haplosporidium nelsoni (*MSX) of Oysters. Website: http://www.pac.dfo-mpo.gc.ca/sci/sealane/aquac/pages/hapneloy.htm

Ford, S.E. and A.J. Figueras. 1988. Effects of sublethal infection by the parasite *Haplosporidium nelsoni* (MSX) on gametogenesis, spawning and sex ratios of oysters in Delaware Bay, USA. Dis. Aquat. Org. 4:121-133.

Ford, S.E. and H.H. Haskin. 1982. History and epizootiology of *Haplosporidium nelsoni* (MSX)*,* an oyster pathogen, in Delaware Bay, 1957-1980. J. Invert. Pathol. 40:118-141.

Ford, S.E. and H.H. Haskin. 1988. Management strategies for MSX (*Haplosporidium nelsoni)* disease in eastern oysters. Ppg. 249-256 in W.S. Fisher (Ed.). Disease Processes in Marine Bivalve Molluscs. Amer. Fish. Soc. Spec. Publ. 18. Bethesda, MD.

Ford, S.E. and M.R. Tripp. 1996. Diseases and Defense Mechanisms. In: . V.S. Kennedy, R.I.E. Newell, and A.F. Eble, Eds. The American oyster: *Crassostrea virginic* . College Park, MD, Sea Grant College, pp. 581-660.

Ford, S.E., H.H. Haskin, and J.N. Kraeuter. 1996. Eastern oyster. In: L.E. Dove and R.M. Nyman (Eds.). Living Resources of the Delaware Estuary. The Delaware Estuary Program. 530 pp. & appendices.

Ford, S.E., R.N. Wargo and L.M. Ragtone. 1988. Metabolic condition and infection levels preceding death in oysters exposed to *Haplosporidium nelsoni* (MSX), with an hypothesis about cause of death. Pp. 41-42, In: Abstracts of 3rd International Colloquium on Pathology in Marine Aqauculture, Gloucester Point, Virginia.

Haskin, H.H. and J.D. Andrews. 1988. Uncertainties and speculations about the life cycle of the eastern oyster pathogen *Haplosporidium nelsoni (*MSX). In: W.S. Fisher (Eds. Disease Processes in Marine Bivalve Molluscs. Amer. Fish. Sox. Spec. Publ. 18 Bethesda, MD. pp. 5-22.

Haskin, H.H. and S. E. Ford. 1982. *Haplosporidium nelsoni* (MSX) on Delaware Bay seed oyster beds: a host-parasite relationship along a salinity gradient. J. Invert. Pathol. 40:388-405.

Haskin, H.H., L.A. Stauber and J.A. Mackin. 1966. *Minchinia nelsoni* sp.n. (Haplosporidia, Haplosporidiidae): causative agent of the Delaware Bay oyster epizootic. Science 153:1414-1416.

Newell, R.I.E. 1985. Physiological effects of the MSX parasite *Haplosporidium nelsoni* (Haskin, Stauber, and Mackin) on the American oyster, *Crassostrea virginica:* feeding and metabolism (Abstract). J. Shellfish Res. 13:294

Issue: MSX Parasite in Oysters
Author: Mary Downes-Gastrich
Version: 05/00

Statewide Analysis of Threat

Threat = MSX (Multinucleated Spore Unknown

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	N/A	N/A	N/A	NA
Marine Waters	3	4	2	24
Wetlands	N/A	N/A	N/A	NA
Forests	N/A	N/A	N/A	NA
Grasslands	N/A	N/A	N/A	NA
			Total Score	24
			Average Score	4.8

Risk by Watershed Management Region

THREAT = MSX	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	N/A	N/A	N/A	N/A
Passaic	N/A	N/A	N/A	N/A	N/A
Raritan	N/A	N/A	N/A	N/A	N/A
Atlantic	N/A	N/A	N/A	N/A	N/A
Lower Delaware	N/A	Low	N/A	N/A	N/A
Region/Watershed (secondary)					
Urban	N/A	N/A	N/A	N/A	N/A
Suburban	N/A	Low	N/A	N/A	N/A
Rural	N/A	Low	N/A	N/A	N/A

H=high, M=medium, L=low;

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Nickel**
Description of stressor	Nickel with atomic no. 28, and atomic wt. 58.69, is a very abundant element. In its elemental form, it is a lustrous-white, hard, ferromagnetic metal, valence 2-3, and a density of 8.90. Cronstedt recognized its elemental nature in 1754 and it was isolated by Berthier in 1820. Nickel occurs free in meteorites; in the environment, it is found primarily combined with oxygen (oxides) or sulfur (sulfides); it is found in many ores in combination with sulfur, arsenic or antimony. Its chief sources are the minerals chalcopyrite, pyrrhotite, pentlandite. Methods of extracting and purifying nickel are described by Ouvrard, et al. (1936). The preparation of high purity nickel is described by Wise & Schaefer (1924). Nickel crystallizes in face-centered cubes. Its melting point is 1455^{o}C. Nickel is stable in air at ordinary temperature; it burns in oxygen, forming NiO. It is not affected by water, but decomposes steam at a red heat. Nickel is slowly attacked by dilute hydrochloric or sulfuric acid; it is readily attacked by nitric acid, but it is not attacked by fused alkali hydroxides. It is found in all soils and is emitted from volcanoes. Nickel has siderophilic properties that facilitate the formation of nickel-iron alloys. In contrast to the soluble nickel salts (chloride, nitrate, sulfate), metallic nickel, nickel sulfides, and nickel oxides are poorly water-soluble. Some of the metals that nickel can be alloyed with are iron, copper, chromium, and zinc. These alloys are used in the making of metal coins and jewelry and in industry for making metal items. Nickel compounds are also used for nickel plating, for various alloys such as new silver, Chinese silver, German silver; for coins, electrotypes, storage batteries; magnets, lightning-rod tips, electrical contacts and electrodes, spark plugs, machinery parts; catalyzer for hydrogenation of oils and other organic substances, to color ceramics, to make some batteries, and as catalysts that increase the rate of chemical reactions. Probably the largest use of nickel is in the manufacture of Raney nickel, monel metal, stainless steels, and nickel-chrome resistance wire. Nickel and its compounds have no characteristic odor or taste. Nickel is an essential element for at least several animal species. These animal studies associate nickel deprivation with depressed growth, reduced reproductive rates, and alternations of serum lipids and glucose. Although there is substantial evidence of an essential status for nickel in animals, a deficiency state in humans has not been clearly defined.
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	
Key impacts selected (critical ecological effects)	

Exposure Assessment	
Exposure routes and pathways considered	Nickel is highly mobile in acidic soils. There is little evidence that nickel compounds accumulate in the food chain. Small nickel particles in the air settle to the ground or are taken out of the air in rain. Much of the nickel in the environment is found with soil and sediments because nickel attaches to particles that contain iron or manganese, which are often present in soil and sediments.
Population(s)/ecosystem(s) exposed statewide	All ecosystems in the state are exposed to nickel since it is a natural component of the soil and sediment. Anthropogenic inputs have resulted in elevated nickel levels in some surface waters, sediments, and soils.
Quantification of exposure levels statewide	Average background Ni soil concentrations in NJ: 6.3 mg/kg (suburban land use; Fields et al., 1993), 8.8 mg/kg (rural land use), 12.2 mg/kg (farm land use; Fields et al., 1993), 15.5 mg/kg (urban Piedmont regions; Wong & Sanders, 1998), and 16.6 mg/kg (urban areas; Fields et al., 1993). In USGS data, Statewide freshwater sampling stations: For Ni in water, one high value, 40 µg/L; if this outlier excluded, mean: 1.4 µg/L (n=44) Sampling for sediments statewide includes data from sediments collected and passed through a 63 µ wet sieve. Such samples are enriched in silts and finer material, compared to the sediment as a whole, and such fine material has a higher concentration of associated contaminants. 1998 USGS samples for Ni in freshwater sediments; mean: 16.4 mg/kg (n=37); range <5 – 43 (DeLuca et al., 1999). Freshwater near hazardous waste sites (NJDEP data): Surface water concentrations ranged from non-detect values (4 sites) to 1 µg/L (1 site) to 50.5 µg/L (1 site) Sediments: average concentration ranged from 6.9 to 43.7 mg/kg (n=56). One wetland site had an average sediment Ni concentration of 18.8 mg/kg (n=11). Sediment concentrations of Ni in the lower Raritan River area ranged from 18-49 mg/kg in tributaries near the Kin-Buc Landfill, and ranged from 16.7 to 551 mg/kg in the Raritan River at the Horseshoe Road Site (Weston, 1996; CDM, 1999). Nickel has been identified as a parameter of concern in water for NY/NJ Harbor. In the Newark Bay complex, Ni exceeded sediment guidance values in 52% of the area studied (Adams et al., 1998). Mean: 48.9 mg/kg (range: 0.15 - 369) (Adams et al., 1998). For Barnegat Bay sediments, mean: 29.8 mg/kg (n=17); in marinas - mean: 29.5 mg/kg (n=4); for pre 1972 strata, mean: 30.5 (n=12) (Moser & Bopp, 1999). Coastal Waters: Surface water Ni concentrations ranged from 0.35-1.9 µg/L in 1988, and 0.25 –0.29 µg/L in 1991 in the New York Bight Apex; and from 0.30-0.39 µg/L in the Mud Dump Site in 1992 (Battelle, 1991; Dragos & Lewis, 1993). Ni concentrations in the New York Bight Apex sediments ranged from 1.9 mg/kg to 160 mg/kg (Krom et al., 1985;

	NOAA, 1982), and Mud Dump Site (HARS) sediment concentrations ranged from <3 mg/kg to 99 mg/kg (Battelle, 1996). Background Ni concentrations in New York Bight sands were < 12 mg/kg (Battelle, 1996). Sediment data from the National Sediment Quality Survey (EPA, 1997) indicated the following Ni concentrations in sediments: **Watershed Location** / **Mean Concentration (ppm)** / **Range (ppm)** Hackensack-Passaic — 11.7 — 1.7 – 100 Sandy Hook-Staten Island — 27.1 — 3.7 - 120 Raritan — 8.3 — 0.6 – 80 Middle Delaware — 3.4 — 0.9 – 36 Lower Delaware — 6.2 — 5 – 60	
Specific population(s) at increased risk		
Quantification of exposure levels to population(s) at increased risk	Benchmark Values **Sediment:** Nickel Freshwater=16 mg/kg (LEL) and 75 mg/kg (SEL) (Persaud et al., 1993) Marine/Estuarine=21 mg/kg (ER-L) and 52 mg/kg (ER-M) (Long et al., 1995) **Surface Water:** Nickel Freshwater (water quality criteria - chronic) =160 µg/l (@ hardness of 100 mg/L) Marine/Estuarine (water quality criteria - chronic) = 8.2 µg/L (NJDEP, 2000) **Soil:** Nickel - 30 mg/kg (based on phytotoxicity; Efroymson et al., 1997)	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed		
Risk Characterization		
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score

Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure		2-3
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)		3
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted		2
	Total	12-15
Assessment of uncertainties in this assessment (H,M,L) and brief description	**H Need more data**	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief	**M – L**	

description. (Data Gaps; highlight significant data needs)	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, !, =, ≡; where + is improvement), and brief description.	**0**
Potential for catastrophic impacts (H,M,L) and brief description	**L**
Link to other Work Groups (e.g., socioeconomic impacts)	
Extent to which threat is currently regulated or otherwise managed	
Barriers to restoration	
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	**M**
Small business industry	**L**
Transportation	**M??**
Residential	**L**
Agriculture	**L**
Recreation	**L**
Resource extraction	**L**
Government	**L**
Natural sources/processes	**L**
Orphan contaminated sites	**M**
Diffuse Sources	
Sediment sinks	

	M
Soil sinks	**?**
Non-local air sources incl. deposition	**?**
Biota sinks	**L**

Issue: Nickel
Author: Tucker
Version: 07/27/00

Summary Statement:
Nickel is a very abundant element in the environment, it is found primarily combined with oxygen (oxides) or sulfur (sulfides); it is found in many ores in combination with sulfur, arsenic or antimony. Nickel can be alloyed with a number of other metals in the making of metal coins and jewelry and in a wide number of industrial and consumer items. Nickel is an essential element for organisms and deprivation causes depressed growth, reduced reproductive rates, and alternations of serum lipids and glucose. Nickel is highly mobile in soil, particularly in acid soils. There is little evidence that nickel compounds accumulate in the food chain. Nickel in toxic amounts affects growth and photosynthesis in aquatic plants and animals, although the toxicity of this and other metals is reduced with increases in the hardness of the water.

Statewide Analysis of Threat **Threat = Nickel**

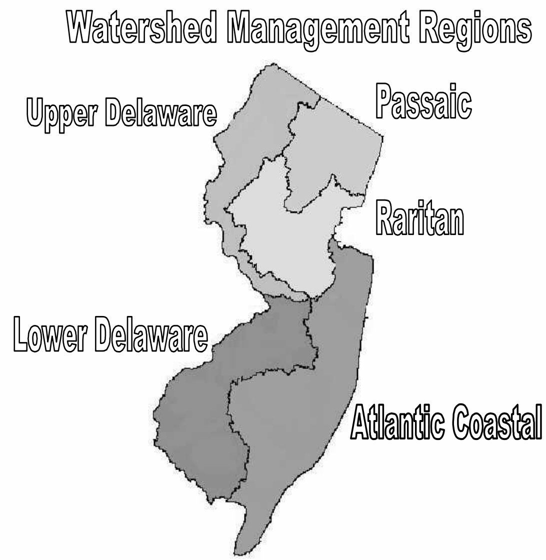
Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	2-3	3	2	12-18 (15)
Marine Waters	2-3	4	3	24-36 (30)
Wetlands	2-3	3	2	12-18 (15)
Forests	2	2	1	4
Grasslands	2	2	1	4
			Total Score	68
			Average Score (Total ÷5)	13.6

Risk by Watershed Management Region

THREAT = Nickel	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	L	NA	L	L	L
Passaic	L-M	M	L-M	L	L
Raritan	L	M	L-M	L	L
Atlantic	L	L	L	L	L
Lower Delaware	L	L	L	L	L
Region/Watershed (secondary)					
Urban	L-M	M	L-M	L	L
Suburban	L	L-M	L-M	L	L
Rural	L	L	L	L	L

H=high, M=medium, L=low, NA = not applicable

Issue: Nickel
Author: Tucker
Version: 07/27/00



References:

Barcan, V.Sh., Kovnatsky, E.F., Smetannikova, M.S. 1998. Absorption of heavy metals in wild berries and edible mushrooms in an area affected by smelter emissions. Water, air, & soil pollution. Dordrecht. vol. 103, no. 1-4, pp. 173-195.

Barceloux, D.G. 1999. Nickel. Journal of Toxicology: Clinical Toxicology. vol. 37, no. 2, pp. 239-258.

Battelle. 1991. Evaluation of Trace-metal Levels in Ambient Waters and Discharges to New York/New Jersey Harbor for Waste Load Allocation. Final Report to the U.S. EPA, Region 2, Battelle Ocean Sciences, Duxbury, MA. Contract No. 68-C3-0105. Work Assignment No. 2-202.

Battelle. 1996. Sediment survey at the Mud Dump Site and Environs. Draft Final Report to U.S. EPA Region 2, New York, NY. EPA Contract No. 68-C2-0134. Work Assignment 3-133.

Berthier. 1820. Ann. Chim. Phys. [2] 14, 52 (1820); 25, 94 (1824).

Burd, G.I. Dixon, D.G. Glick, B.R. A plant growth-promoting bacterium that decreases nickel toxicity in seedlings. Applied & Environmental Microbiology. October 1998. vol. 64, no. 10, pp. 3663-3668.

Cantoni, M., O. Klein, C. Rossman, T. Snow, E. Suk, W. Environmental Health Perspectives. vol. 102, no. 3 Suppl. Available as: Molecular Mechanisms of Metal Toxicity and Carcinogenicity. 1994. pp. 297-300.

CDM. 1999. Final Remediation Investigation Report, Horseshoe Road Complex Site, Remedial Investigation/Feasibility Study, Sayreville, NJ. CDM Federal Programs Corp. for U.S. EPA, Region II.

Cronstedt. 1758. Mineralogie 218, Stockholm.

Dragos, P., and D. Lewis. 1993. Plume Tracking/Model Verification Project. Report prepared by Battelle Ocean Sciences for the U.S. EPA, Region 2, New York. EPA Contract No. 68-C8-0105. 62 pp. + appendix.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. (1997a). Toxicological benchmarks for contaminants of potential concern for effects on terrestrial plants: 1997 Revision. Prepared for U.S. Department of Energy, Oak Ridge National Laboratory by Lockheed Martin Energy Systems, Inc. 123 p.

Fields, T. W., McNevin, T.F., Harkov, R.A., and Hunter, J.V. (1993). A summary of selected soil constituents and contaminants at background locations in New Jersey. New Jersey Department of Environmental Protection.

Francis, A.J. Joshi-Tope, G.A. Dodge, C.J. Biodegradation of nickel-citrate and modulation of nickel toxicity by iron. Environmental Science & Technology. 1996. vol. 30, no. 2, pp. 562-568.

Jin, X. Nalewajko, C. Kushner, D.J. Comparative study of nickel toxicity to growth and photosynthesis in nickel-resistant and -sensitive strains of *Scenedesmus acutus* F. *alternans* (Chlorophyceae). Microbial Ecology. February 1996. vol. 31, no. 1, pp. 103-114.

Jin, X.. Nickel Toxicity and Mechanisms of Nickel Resistance in *Scenedesmus acutus* f. *alternans*. Dissertation Abstracts International Part B: Science & Engineering. July1999. vol. 60, no. 1, p. 87.

Kallanagoudar, Y.P. Patil, H.S. Influence of water hardness on copper, zinc and nickel toxicity to *Gambusia affinis* (B & G). Journal of Environmental Biology. 1997. vol. 18, no. 4, pp. 409-413.

Krom, M.D., K.K. Turekian, and N.H. Cutshall. 1985. Fate of Metals in the Sediments of the New York Bight, Chapter 9. Pp. 209-234 *in* B.H. Ketchum, J.M. Capuzzo, W.V. Burt, I.W. Duedall, P.K. Park, D.R. Kester, Eds., Wastes in the Ocean, Volume 6. John Wiley & Sons, New York, NY.

Littlefield, N.A. Hass, B.S. James, S.J. Poirier, L.A. Protective effect of magnesium on DNA strand breaks induced by nickel or cadmium. Cell Biology & Toxicology. 1994. vol. 10, no. 2, pp. 127-135.

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Nanda, P. Nickel toxicity to liver and brain of a catfish *Heteropneustes fossilis* (Bloch). Environment & Ecology. June 1997. vol. 15, no. 2, pp. 329-331.

Ouvrard, et al., 1936. cited by Mellor, A Comprehensive Treatise an Inorganic and Theoretical Chemistry, 15, 15

NJDEP. 2000. Surface Water Quality Standards (SWQS) Criteria Currently Applicable to New Jersey Surface Waters. Memorandum, Division of Watershed Management.

NOAA. 1982. Contaminants in New York Bight and Long Island Sound Sediments and Demersal Species, and Contaminant Effects on Benthos, Summer 1980. NOAA Technical Memorandum NMFS-F/NEC-16. Northeast Monitoring Program. Woods Hole, MA. 97pp.

Pereira, M.C. Pereira, M.L. Sousa, J.P. Evaluation of nickel toxicity on liver, spleen, and kidney of mice after administration of high-dose metal ion. Journal of Biomedical Materials Research. vol. 40, no. 1, pp. 40-47. John Wiley & Sons, Inc. NC, April 1998.

Stadt, K.J. Taylor, G.J. Dale, M.R.T. Measuring the effect of an abiotic stress on competition. Oecologia. 1994. vol. 100, no. 3, pp. 221-228.

U.S. EPA. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, Volume 2: Data Summaries for Areas of Probable Concern. Office of Science and Technology, Washington, DC.

Weston, Roy F., Inc. 1996. Draft Raritan River Surface Water and Sediment Literature Review and Sampling Plan for the Former Raritan Arsenal. Contract No. DACA 41-92-D-8002. Prepared for the U.S. Army Corps of Engineers, New England Division.

Wise & Schaefer. 1924. Metals and Alloys16, 424.

Wong, D. M. W. and Sanders, P.F. (1998). Characterization of ambient levels of metals and polycyclic aromatic hydrocarbons for surficial soil in the urban Piedmont region of New Jersey. Environmental Toxicology and Risk Assessment: Seventh Volume, ASTM STP 1333, E.E. Little, A.J.

Wu, Long-Fei. Navarro, C. De Pina, K. Quenard, M. Mandrand, M.-A. Antagonistic effect of nickel on the fermentative growth of Escherichia coli K-12 and comparison of nickel and cobalt toxicity on the aerobic and anaerobic growth. Meeting 2. International Meeting on Molecular Mechanisms of Metal Toxicity and Carcinogenicity, 10-17 Jan 1993, Madonna di Campiglio (Italy). Editor Costa,

Issue: Nitrogen Pollution (water)
Author: Thomas
Version: 04/05/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Nitrogen Pollution (Water)**
Description of stressor	Global, regional, and local nitrogen cycles have been significantly disrupted by use of nitrogen fertilizers and by combustion, which produces nitrogen oxides (Vitousek, 1999; Socolow, 1999). The forms of nitrogen of particular environmental concern include dissolved organic nitrogen (DON), particulate nitrogen (PN), the nutrients ammonium (NH_4^+) and nitrate (NO_3^-) ions in water, the nitrogen gases nitric oxide (NO) and nitrogen dioxide (NO_2) (collectively referred to as NOx), and the gas nitrous oxide (N_2O).
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Ammonium (NH_4^+) can be toxic to fish, and the natural conversion of ammonia to nitrate (NO_3^-) can result in oxygen depletion in aquatic ecosystems. Excess nitrogen in water (NO_3^-, DON, and NH_4^+) can contribute to eutrophication, especially in estuaries and coastal waters. NOx , DON and NH_4^+ contribute to regional air pollution and to acid precipitation, and deposited NOx , DON, and NH_4^+ contribute significant amounts of nitrogen to both aquatic and terrestrial ecosystems. Ecosystem disruption can result from uneven species responses to nitrogen fertilization across species (Vitousek, 1999). Nitrous oxide (N_2O) in the atmosphere contributes to the greenhouse effect and to the destruction of stratospheric ozone.
Key impacts selected (critical ecological effects)	High levels of nitrogen in estuaries and marine waters can cause eutrophication, which in turn can result in algal blooms and low dissolved oxygen (DO) levels. Low DO concentrations, referred to as hypoxia, often occur in the coastal waters of portions of the State during the summer months. The ecological effects of eutrophication and hypoxia are severe. Eutrophic waters will often experience massive algal blooms. These blooms can and have resulted in noxious odors, depletion of dissolved oxygen in bottom waters, mass mortality of finfish and shellfish, and die-off of submerged aquatic vegetation. Only the water quality impacts of nitrogen are considered here. The contribution of NOx to acid deposition, and the global warming and stratospheric ozone depletion impacts of N_2O are considered in separate assessments. Fertilization effects of nitrogen deposition on terrestrial ecosystems may be significant, but are not yet well understood (Vitousek, 1999).

Issue: Nitrogen Pollution (water)
Author: Thomas
Version: 04/05/00

Exposure Assessment	
Exposure routes and pathways considered	Freshwater ecosystems receive excess nitrogen runoff from fertilizers and manure used in agriculture, and from fertilizer runoff from residential, commercial and urban applications. Sewage treatment plants release nitrogen to streams and rivers, and septic tanks release nitrogen to groundwater, which can enter surface streams and lakes. Estuaries and coastal ecosystems receive nitrogen from rivers, and they also receive deposition of atmospheric NOx and DON. Atmospheric NOx is produced by combustion processes, such as coal combustion and transportation fuel combustion, because temperatures above 1500°C break apart atmospheric N_2 and form nitrogen oxides.
Population(s)/ecosystem(s) exposed statewide	Both freshwater and coastal ecosystems are exposed to excess nitrogen. Typically, freshwater ecosystems in New Jersey are phosphorus-limited, while estuarine and coastal ecosystems are nitrogen-limited. Thus excess nitrogen may have little impact on freshwater ecosystems but significant impact downstream in estuaries and coastal waters. All ecosystems receive excess nitrogen from air deposition.
Quantification of exposure levels statewide	Typical inorganic nitrogen levels in New Jersey rivers and streams range from less than 1 ppm to 3 ppm or higher. Areas with especially high nitrate concentrations include South River in the Lower Raritan Watershed (WMA 9), which in 1996 had one sample exceeding 10 ppm (NJ DEP 1999). Typical inorganic nitrogen levels in New Jersey coastal waters are in the range of 0.4 to 0.6 ppm. Typical DON levels in New Jersey coastal waters are in the range of 0.3 to 0.7 ppm (Seitzinger, 2000)
Specific population(s) at increased risk	Ammonia is toxic to fish, with trout being the most sensitive species. Trout waters are found primarily in the northwest part of New Jersey.
Quantification of exposure levels to population(s) at increased risk	The only exceedences of ammonia criterion in 1996 were in the Upper Delaware watershed (WMA 1), where 3 out of 23 samples at Musconnetcong exceeded 20 ppm, and in the Raritan watershed (WMA 8), where one sample in trout waters contained 85 ppm ammonia. In the Lower Passaic River Basin (WMA 4), a non-trout watershed, ammonia levels are high (median of 12 ppm, maximum of 40 ppm) but within the non-trout criterion of 50 ppm.

Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	Nitrogen as a nutrient: A dose-response relationship between nitrogen input and aquatic plant growth in coastal bays and estuaries does not yet exist (USGS, 1999). The NJ water quality standard for nitrate for all areas except the Pinelands is 10 ppm, but this standard is based on the potential for human health effects, not on ecological impacts (US EPA, 1976). Background levels of nitrate are typically less than 1 ppm. Levels greater than 1 ppm are considered to be elevated. Oxygen levels less than 4 mg DO/L are recognized as stressful to aquatic biota. As concentrations fall to or below that level, mobile organisms such as fish begin to leave the affected area; less mobile organisms can become stressed and die. At DO concentrations of 3 mg/L and below, effects become progressively more severe. For example, at DO concentrations at 1.5 to 3 mg/L, many organisms leave or die within days to weeks; most organisms die when concentrations below 1.5 mg/L persist for a few days or more. Ammonia Toxicity: The criterion for ammonia is 20 ppb in waters where trout live and reproduce and is 50 ppb in waters not appropriate for trout.
Risk Characterization	
Risk estimate(s) by population at risk	Between 1989 and 1994, approximately 15% of the State's coastal waters experienced oxygen levels recognized as stressful to aquatic biota (<4 mg DO/L). During 1993-1997 half of New Jersey's coastal water quality monitoring stations had unacceptably low dissolved oxygen, with most of these stations between Barnegat and Great Egg Harbor. Periodic red tide blooms have appeared in the Raritan and Sandy Hook Bays. The low DO concentrations coincided with phytoplankton blooms, indicating that excess nitrogen was a causal factor. A national survey on eutrophication in estuarine waters of the United States ranked New Jersey's estuaries high to very high for existing eutrophic conditions. Eutrophication has been confirmed by data from the New Jersey Phytoplankton Survey, which measures chlorophyll a values (an indicator for phytoplankton levels and eutrophic conditions) at 14 stations along the coastline from Raritan Bay to the Delaware Bay. Data from these stations show that the Raritan Bay has very high intensity and high frequency blooms, the Delaware Bay near Cape May County has chronic but benign red tides and most other areas along the coast have levels considered slightly above normal throughout the entire summer season.

Issue: Nitrogen Pollution (water)
Author: Thomas
Version: 04/05/00

		Score
Assessment of severity/irreversibility	Nitrogen as a nutrient: Oxygen depletion in marine and estuarine waters affects population abundance and distributions (3). Ammonia Toxicity to trout affects population abundance and distributions (3).	3 3
Assessment of frequency of effect(s)	Nitrogen as a nutrient: Anoxic conditions in NJ coastal waters occur annually and seem to be getting worse. Ammonia Toxicity: Ammonia levels in NJ freshwater have been decreasing as sewage treatment plants have been improved (3).	4 3
Size of population(s) and/or extent of the State/habitat affected (magnitude)	Nitrogen as a nutrient: All NJ coastal waters receive excess nitrogen, and are affected to varying extents (5). Ammonia: About 10% of trout habitats exceed the ammonia criterion. (2)	5 2
	Total (for nitrogen as a nutrient in coastal waters) Total (for ammonia toxicity in inland waters)	60 18
Assessment of uncertainties in this assessment (H,M,L) and brief description	M. The causes of oxygen depletion in coastal waters are not yet completely understood. While nitrogen is firmly identified as a causal factor, other factors such as warmer weather may also be important.	
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description. (Data Gaps; highlight significant data needs)	M. Fuller understanding of the nitrogen cycle could shift the concern from local water quality to regional water quality, terrestrial ecosystems, and to the global climate.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, , =, where + is improvement), and brief description.	(0) There is some evidence that total nitrogen concentrations in NJ coastal waters are decreasing. However, the levels of dissolved oxygen in NJ estuaries and marine waters has been decreasing (that is, getting worse) since 1989.	
Potential for catastrophic impacts (H,M,L) and brief description	(L) Increasing levels of atmospheric N_2O contribute to climate change.	
Link to other Work Groups (e.g., socioeconomic impacts)	Nitrates in drinking water and atmospheric NOx present significant threats to human health. N_2O is a greenhouse gas and depletes stratospheric ozone. The impacts of nitrogen on estuarine and marine waters have socio-economic impacts.	

Issue: Nitrogen Pollution (water)
Author: Thomas
Version: 04/05/00

Extent to which threat is currently regulated	Fertilizer runoff is not regulated, nor is nitrate loading from domestic septic systems. Large flow onsite sewage disposal systems such as strip malls, schools and small businesses located in areas not served by public sewers also generate significant nitrate loading, but these sources required to comply with NJPDES permits issued by the NJ DEP. NOx emissions from combustion sources are regulated.
Barriers to restoration	
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	The primary sources of nitrogen to aquatic ecosystems are fertilizers, manure, atmospheric deposition of nitrogen compounds from combustion, and septic systems.
Large business/industry	x (NOx from power plants and other combustion contributes to nitrogen deposition)
Small business industry	
Transportation	x (NOx from automobiles contributes to nitrogen deposition)
Residential	x (from fertilizer runoff and septic systems)
Agriculture	x (from fertilizer and manure runoff)
Recreation	
Resource extraction	
Government	x (from sewage treatment systems)
Natural sources/processes	x
Orphan contaminated sites	
Diffuse Sources	
Sediment sinks	
Soil sinks	
Non-local air sources incl. deposition	x
Biota sinks	

Issue: Nitrogen Pollution (water)
Author: Thomas
Version: 04/05/00

References:

Bowers, F. H. Septic Systems and Nitrate Nitrogen as Indicators of Ground Water Quality Trends in New Jersey. NJ DEP, Division of Water Quality. 1999.

NJ DEP 1999. New Jersey 1996 State Water Quality Inventory Report.

NJ DEP, 1998. Report to EPA. A Self-Assessment of New Jersey's Environment and the Programs of the New Jersey Department of Environmental Protection (NEPPS) (March)

NJ DEP, 1998. Environmental Indicators Technical Report. NEPPS. (June).

NJ DEP, 1999. NJ Ambient Monitoring Program Report on Marine and Coastal Water Quality 1993-1997. (October). NJ DEP Division of Watershed Management.

Seitzinger, S. 2000. Personal communication. Institute of Marine and Coastal Sciences. Rutgers University. Nov. 10.

Socolow, R. H. Nitrogen Management and the Future of Food: Lessons from the Management of Energy and Carbon. Proc. Nat. Acad.. Sci, 1999.

US EPA. 1976. Quality Criteria for Water.

US Geological Survey (USGS), 1999. The Quality of Our Nation's Waters.

Vitousek, P. M. et al. Human Alterations of the Global Nitrogen Cycle: Causes and Consequences. Spring 1997. Issues in Ecology 1:1-15.

Issue: Nitrogen Pollution (water)
Author: Thomas
Version: 04/05/00

Statewide Analysis of Threat

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	3	3	2	18
Marine Waters	3	4	5	60
Wetlands	3	4	5	60
Forests	2	3	1	6
Grasslands	2	3	1	6
			Total Score	138
			Average Score	27.6

Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	M	H	M	L	L
Passaic	M	H	M	L	L
Raritan	M	H	M	L	L
Atlantic	M	H	H	L	L
Lower Delaware	M	H	H	L	L
Urban	M	H	M	NA	NA
Suburban	M	H	M	NA	L
Rural	M	H	M	L	L

H=high, M=medium, L=low;

Issue: Noise
Author: Bergstein
Version: 04/05/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Noise** Noise generated from commercial and military aircraft overflights, small private propeller/small jet, and helicopter activity.
Description of stressor	Turbofan and turbojet engines are major sources of intense aircraft noise. Turboprop-powered aircraft also used by the U.S. Air Force (contribution to overall noise environment nationally &within New Jersey is relatively minor) This noise is composed of a wide range of frequencies, but major portion is at the lower end of the frequency spectrum. There is a broad band frequency distribution of jet noise (about 200-20,000 Hz) versus the low frequency noise of sonic booms(with most of the sound energy between 15-50Hz).
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Disruption and potential harm to animals in state park, river and stream corridors, beaches & shorelines, wetlands and refuge areas; effects on the productivity of domestic animals. Primary Impacts thought to be disruption of a species' ability to communicate; secondary effects of aircraft noise and sonic booms include nonauditory effects as stress, behavioral changes, interference with mating
Key impacts selected (critical ecological effects)	Domestic animals and wildlife exhibit a startle response. Adverse effects could affect predator-prey relationships, reproductive failure, intra- and interspecies behavior patterns, and nutritional deficiencies. (Manci et al.)
Exposure Assessment	
Exposure routes and pathways considered	Direct exposure to overflight noise propagated by commercial, military and private aircraft & helicopters
Population(s)/eco-system(s) exposed statewide	There is a concentrated number of public use, special use, restricted use airports and heliport facilities around the state. This poses overflight of virtually every point within New Jersey by a variety of aircraft emitting noise along a wide spectrum. Natural resources potentially exposed to overflight noise include special use lands, river and stream corridors, beaches and shorelines, forests, wetlands totaling approximately 1.5 million acres in New Jersey.
Quantification of exposure levels statewide	Based on data from the state's 16 airports reporting to FAA's ACAIS Database, 16,961,121 people enplaned in New Jersey in 1998. Top 3 airports which made up 99% of this figure were: Newark International- 16,378,607; Atlantic City International-484,530; and Trenton Mercer-92,472
Specific population(s) at increased risk	nesting shorebirds in the vicinity of heliports and airports. Birds and waterfowl have responded to low level helicopters associated with the casino industry in Atlantic City(Edwin B. Forsythe National Wildlife Refuge). Snow geese and brant evacuate the area when helicopters are over a mile away, not settling down until several minutes after the helicopter has

	cleared the area. The refuge is a primary wintering area for brant and stopover for snow geese, under the most direct route to the large metropolitan areas in northern New Jersey (Gladwin et. al 1988)	
Quantification of exposure levels to population(s) at increased risk	Not possible with available data	
Dose/Impact-Response Assessment		
Quantitative impact-assessment employed	Not enough data available to quantify dose/impact relationship between overflight noise in New Jersey and its effect on particular species.	
Risk Characterization		
Risk estimate(s) by population at risk	Population at risk - birds/waterfowl in vicinity of helicopter flight paths	Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 – Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced. Short time for recovery	1. Short-term evacuation of nesting areas has been observed with the low overflight of helicopter craft. Although there are indications of more extreme startle response resulting from supersonic transport fly over, SST flight operations within the state are a negligible percentage of the total.	2

2 – Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	2. Based on data for Newark Airport, nighttime departures and arrivals account for significantly less operations than do daytime arrivals and departures. Data gathered by surveillance radar at several localities in the U.S. and Canada indicates considerably more birds migrate at night than during the day (Gauthreaux, 1975). Accordingly, if flight operations maintain a primarily day vs. night schedule, birds in migration will encounter lesser overflight noise impacts.	
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Noise impacts of commercial aircraft to wildlife are minimal due to rapid ascent/descent of the craft. However, because of their lower elevation of operation, overflight noise from helicopters may pose greater ecological impacts. There are over 400 heliports in NJ. Further development of these facilities, construction of new heliports, and the hours of operation should be investigated with	4

Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	respect to noise compatibility planning. Resident wildlife populations within the State's over 1.5 million acres of natural areas (i.e., parks, refuges, wilderness), particularly along the eastern portion of the State ranging from Monmouth-Cape May Counties. Approximately 10 % of the State's heliports operate within two miles of the coastline from Monmouth-Cape May Counties. This zone is in close proximity to about half the national wildlife refuge areas in the State, and the eastern fringe of the Pinelands National Reserve.	3
	Total	24
Assessment of uncertainties in this assessment (H,M,L) and brief description	(H): There is no conclusive evidence that overflight noise has significant ecological effects upon wildlife, because it has not been well studied in New Jersey. While louder commercial aircraft are being phased out pursuant to FAA regulations, this effect may be negated by the increase in flights within the state.	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	(M): A significant amount of field observation has been conducted on the reactions of animals to overflight noise, primarily in areas outside of the state. It has proven difficult to draw any general conclusions on the subject because there is variability in response both between and within species. In contrast to subsonic aircraft, supersonic transports pose more noticeable impacts through overflight. In Jamaica Bay Recreational Area, near JFK Airport in NY, significantly more nesting gulls flew from their nests, and engaged in more fights when they landed compared with the other conditions. Many eggs were broken during these fights, and eggs were	

	subsequently eaten by intruders. -This would suggest the need to evaluate SST flight paths over wildlife resource areas in NJ and evaluate different impact scenarios of SST operations over time. (Currently, SST flights account for a small percentage of total operations within the State as noted on page 2.)
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description.	(–) National figures indicate a 79 percent increase in passenger mileage and an 86% increase in air cargo mileage from 1980-1990. The trend in air cargo traffic will continue over the next decade. (Suter 1991) Although there will be a reduction of noisier stage II aircraft by the year 2004, the growth of air transportation and need for airport expansion may offset the benefits of the quieter aircraft. Within the state we see a distinct increase in air travel, hence a potential increase in overflight noise impacts. As an example, the difference in enplanements for Newark International Airport indicates a 974,930 passenger increase between 1996-1997, and a nearly commensurate increase of 945,981 enplanements between 1997-1998. (FAA DOT/TSC ACAIS Database)
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope) Link to other Work Groups (e.g., socioeconomic impacts)	L- potential for catastrophic impacts to biota is considered to be low since 3% of flight activity within the state occurs in the area containing sensitive species. However, noise monitoring of overflight coupled with field observations would need to be undertaken to make a more accurate judgement. Human Health/related issues- (1) To evaluate a possible linkage to overflight noise, the Federal Interagency Committee on Aviation Noise plans to sponsor a symposium to address the effects of aviation noise on children and learning in early 2000. The Centers for Disease Control and Prevention's (CDC) National Center for Environmental Health (NCEH) conducted an analysis to determine the prevalence of hearing loss among children using data collected from 1988-1994 in the Third National Health and Nutrition Examination Survey. The analysis indicates that 14.9% of U.S. children have low or high frequency hearing loss of at least 16 dB hearing level in 1 or both ears. Among children in elementary, middle, and high school, audiometric screening should include low-frequency and high-frequency testing to detect hearing loss.
	Socioeconomics- Overflight noise has been linked to annoyance. An example is the complaints raised by citizen groups about the overflight noise increases resulting from the Expanded East Coast Plan at Newark International Airport. A common complaint has been the drop in property values in those areas that are overflown. (NJIT Report)

Extent to which threat is currently regulated or otherwise managed.	This issue is evaluated pursuant to : Section 102(2) (c) of the National Environmental policy Act of 1969 (P.L. 91-190) FAA 14CFR part 91 and 161(February 28, 1991) which implements the Airport Noise and Capacity Act,PL101-508 (November 5, 1990). Part 91 requires phaseout of Stage 2 aircraft greater than 75,000-lb. takeoff weight in the 48 contiguous states by December 31, 1999. 49 USC 47529 Nonaddition rule- This section states that subsonic turbojets "imported" into this country after 1990 must comply with stage 3 noise levels, unless the Secretary grants an exemption in order to allow the carrier to modify the aircraft to meet those levels. Then the section defines "imported", clarifying which aircraft owners must comply with the rule. 49 USC 47502 Noise measurement and exposure systems and identifying land use compatible with noise exposure This section requires the Secretary of Transportation to consult with state and other federal agencies in order to establish reliable and uniform systems of measurement for noise and noise exposure. The Secretary must also identify land uses compatible with various noise exposures. 42 USC 4913 Quiet communities, research, and public information. This section promotes State and local noise control programs. It lists goals for a Federal noise control program, such as developing and distributing information on noise health effects and control using various educational channels and research, or financing research concerning noise effects, measurement, and control. The section authorizes the Quiet Communities Program, which offers state, regional, and local grants to study noise abatement and collect data, buy monitoring equipment, and provide technical assistance for noise control. 49 USC 47509 Research program on quiet aircraft technology for propeller and rotor driven aircraft This section requires the Administrators of the FAA and NASA, in cooperation with aircraft industry professionals, to review the current propeller and rotor aircraft "quiet technology" research status in order to determine if supplemental study is warranted. If necessary, further research would require the development of noise reduction technology that substantially reduces propeller and rotocraft noise levels.
Barriers to restoration	Lack of knowledge: -Uncertainty about location of military flight operations within state and whether low altitude military operations will increase, decrease or remain the same. -The question of how adaptable animals are remains largely unanswered. (Mar. 85FAA Report) Few studies have examined the effects of noise on wildlife at the population level.

	-Hearing ability of many species has not been investigated. More studies to determine this ability are needed to improve the ability to accurately assess the potential effects of noise on individual species. -Noise measurement monitoring station locations within the state do not correspond to wildlife areas south of Monmouth County and along the western fringe to evaluate noise impacts to wildlife in those areas.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	L
Small business industry	L
Transportation	H
Residential	N/A
Agriculture	N/A
Recreation	L
Resource extraction	N/A
Government	M-Need to check(military aircraft operations conducted inland & offshore)
Natural sources/processes	N/A
Orphan contaminated sites	N/A
Diffuse Sources	
Sediment sinks	N/A
Soil sinks	N/A

Non-local air sources incl. deposition	N/A
Biota sinks	N/A

Statewide Analysis of Threat

Threat = Overflight Noise

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	2	3	2	12
Marine Waters	2	3	2	12
Wetlands	2	3	2	12
Forests	2	3	2	12
Grasslands	2	3	2	12
			Total Score	60
			Average Score	12

Issue: Noise
Author: Bergstein
Version: 04/05/00

Risk by Watershed Management Region

THREAT = Overflight Noise	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	L	NA	L	L	L
Passaic	L	L	L	L	L
Raritan	L	L	L	L	L
Atlantic	L	L	L	L	L
Lower Delaware	L	L	L	L	L
Region/Watershed (secondary)					
Urban	L	L	L	L	L
Suburban	L	L	L	L	L
Rural	L	L	L	L	L

H=high, M=medium, L=low;

References

Black, B.B., M.W. Collopy, H.F. Percival, A.A. Tiller, and P.G. Bohall. 1984. Effect of low-level military training flights on wading bird colonies in Florida. Florida Coop. Fish Wild. Res. Unit, Sch. For. Res. Conserv., University of Florida, Gainesville. Tech. Rep. 7. 190 pp.

Burger, J. 1981. Behavioral responses of herring gulls (Larus argentatus) to aircraft noise. Envir. Pollut. (Ser. A) 24:177-184.

EPA (Memo to Regional Air Division Directors), 11/29/99. Efforts to Reduce Aviation-Related Emissions. 2 pp.

FAA DOT/TSC ACAIS Database, 1996,1997,& 1998

Issue: Noise
Author: Bergstein
Version: 04/05/00

Federal Aviation Administration, 1985, Aviation Noise Effects

Fletcher, J.L., 1980. Effects of noise on wildlife: a review of relevant literature 1971-1978. Pages 611-620 in J.V. Tobias, G. Jansen, and W.D. Ward, eds. Proceedings of the Third International Congress on Noise as a Public Health Problem. Am. Speech-Language-Hearing Assoc., Rockville, MD.

Fletcher, J.L., 1990. Review of noise and terrestrial species: 1983-1988. pp. 181-188 in: B. Berglund and T. Lindvall, eds. Noise as a Public Health Problem Vol. 5: New Advances in Noise Research Part II. Swedish Council for Building Research, Stockholm

Gauthreaux, Sidney A., Jr., "Migratory Behavior and Flight Patterns" Impacts of Transmission Lines on Birds in Flight. Proceedings of a Conference, Jan. 31-Feb. 2, 1978. Oak Ridge TN, June 1978.

Gladwin, D.N., D.A. Asherin, and K.M. Manci. 1987. Effects of aircraft noise and sonic booms on fish and wildlife: results of a survey of U.S. Fish and Wildlife Service Endangered Species and Ecological Services Field Offices, Refuges, Hatcheries, and Research Centers. NERC-88/30. U.S. Fish Wild. Serv., National Ecology Research Center, Fort Collins, CO. 24 pp.

Gladwin, D.N., K.M. Manci, and R. Villella. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: bibliographic abstracts. U.S. Fish Wild. Serv. National Ecology Research Center, Ft. Collins, CO. NERC-88/32. 78 pp.

Manci, K.M., D.N. Gladwin, R. Villella, and M.G. Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis. U.S. Fish and Wild. Serv. National Ecology Research Center, Ft. Collins, CO.
NERC-88/29. 88 pp.

National Park Service, 1994. Report to Congress, Report on effects of aircraft overflights on the National Park System.

New Jersey Institute of Technology, January 28, 1999, STRATEGIES TO EVALUATE AIRCRAFT ROUTING PLANS

Shotton, L.R. 1982. Response of wildlife and farm animals to low-level military jet overflight. Rep. II(6):161-164.

Suter, Alice H., November 1991, Noise and Its Effects, Administrative Conference of the United States

U.S. Air Force. 1985. Final Environmental Impact Statement: establishment of the Gandy Range extension and adjacent restricted airspace as an area for supersonic flight training, Hill AFB, Utah. Public Affairs Office, Hill Air Force Base, Utah. 96 pp. + appendices.

Personal Communication- Mo Keane, FAA 1/25/00

Websites- http://www.state.nj.us./transportation/gis/maps/airports.pdf

Issue: (Boat-Recreational) Noise
Author: Dobkowski-Joy
Version: 12/28/99

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Noise (Boat-Recreational)** 1. Underwater noise caused by coastal shipping lane traffic, undersea naval signals and experimental broadcasts. 2. Noise emitted by recreational vehicles such as jet skis, all terrain vehicles, and snowmobiles.
Description of stressor	1. Underwater noise: Background ocean noise due to ship traffic, especially near port areas, may disrupt communication among marine mammals. Also, naval and scientific experiments that employ acoustic methods to explore oceanic conditions may emit short term sound blasts of up to 235dB. Whales and other marine mammals may suffer temporary or permanent hearing impairment or deafness upon exposure to these noise levels (Holmes, 1997). As New Jersey waters host many different species of whales, dolphins, and sea turtles at various times throughout the year (NJ Marine Mammal Stranding Center), underwater noise pollution may be having an adverse effect upon these populations. 2. Jet Ski Noise: Jet skis produce high frequency sounds that disturb birds and other near shore animals. Observations of nesting terns and ospreys in New Jersey have shown that birds leave their nests for extended periods of time when disturbed by jet skis, potentially subjecting their eggs to predation danger (Burger, 1998). The inconsistency in jet ski noise does not provide appropriate warning for animals in the jet skis' path, causing panic and potentially increased rates of injury and death due to collision (Woods Hole Oceanographic Institute, 1996).
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Biological Integrity: Intense noise events causing deafness or hearing impairment, as well as continuous low-level background noise directly impact the ability of marine mammals to forage for food, avoid predators, navigate, and communicate with others of their species (Holmes,1997; Sehgal, 1995). Ecosystem Function: Noise disturbances from jet skis in near shore areas flush birds and other animals from their habitat, disrupting breeding and feeding activities (Blue Water Network Website, 1999; Burger, 1998).
Key impacts selected (critical ecological effects)	1. Injury/impairment to marine mammal functioning due to excessive noise 2. Disruption and injury caused by jet ski noise
Exposure Assessment	
Exposure routes and pathways considered	Direct exposure to undersea noise and recreational noise pollution.

Issue: (Boat-Recreational) Noise
Author: Dobkowski-Joy
Version: 12/28/99

Population(s)/ecosystem(s) exposed statewide	1. Oceanic noise Populations of marine mammals living in the near shore and continental shelf environment off the coast of New Jersey. 2. Jet Ski Noise Jet skis are currently allowed in the Gateway national recreation area, the Delaware Water Gap, as well as in other locations throughout the state of New Jersey (Associated Press, 1998). All potentially affected populations of birds and other species were considered.
Quantification of exposure levels statewide	Not possible with available data
Specific population(s) at increased risk	Nesting shorebirds near jet ski recreation areas
Quantification of exposure levels to population(s) at increased risk	Not possible with available data
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	Not enough data available to quantify dose/ impact relationship between noise pollution in New Jersey and its effect on particular species.
Risk Characterization	

Risk estimate(s) by population at risk	Population at risk includes near shore and offshore marine mammals, and near shore animals in jet ski recreation areas.	**Score**
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions	1. Oceanic noise: Score=2 Current background noise levels are estimated at 85 dB (Holmes, 1997). 2. Jet Skis: Score= 2+ Effects localized to jet ski recreation areas during daylight hours in the warmer months of the year.	2

reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure		
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	1. Oceanic Noise: Score for high intensity noise=3 Constant background noise near shipping lanes, potential occasional episodes of high frequency noise emission. 2. Jet Ski Noise Pollution: Score=3 Jet skis are most frequently utilized during the warm weather months in near shore areas and on inland lakes. However, there is insufficient data to determine the frequency of jet ski use.	3
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	Estimated at 5-10% of the state affected. Limited to populations of migrant marine mammals, and inhabitants of jet ski recreation areas. Magnitude is difficult to ascertain, especially in the long term.	2
	Total	12
Assessment of uncertainties in this assessment (H,M,L) and brief description	H There is no conclusive evidence that underwater background noise has significant effects upon marine mammals, although this may change if noise levels rise. It is also difficult to determine the level of risk in State of New Jersey waters, given that marine mammals travel throughout a large range. In terms of jet ski-related noise, Burger's 1998 study of jet ski effects on Common Terns indicates that "waterfowl respond significantly more" to jet skis as compared with standard motorboats. However, very little quantitative data can be found describing specific and/or significant risks of noise pollution due to jet skis.	
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description (Data Gaps; highlight significant data needs)	(M) Lack of research on the effects of increasing undersea noise on marine mammals and other ocean-dwelling creatures. Lack of data on the effects of noise pollution caused by human recreational activities in New Jersey.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, –, =, ≡ where + is improvement), and brief description.	(–) Oceanic noise levels may increase slowly, but it is unclear what effects will result. Recreational noise will probably be regulated by local ordinances and laws if enough people view it as a nuisance (although sales of jet skis are climbing	

	rapidly) (Bluewater Network, 1999; Nelson, 1998).
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	L: Potential for drastic impacts on a wide area are low.
Link to other Work Groups (e.g., socioeconomic impacts)	Oceanic noise may be regulated, thus forcing shipping companies to install noise abatement equipment, but this effect would probably be minor as compared with other shipping expenses. Noise pollution caused by recreation may cause human health problems if noise levels exceed 85-105dB (above which temporary or permanent hearing impairment may result) (American Hospital Association)(Nelson, Surfrider Foundation, 1998). There are socio-economic links to the use of jet skis and snowmobiles relating to the enjoyment value of their use versus the enjoyment value to others of a peaceful and quiet environment (especially in public areas such as national parks). A survey of New Jersey residents regarding coastal recreation found that interviewees cited jet skis as the number one environmental problem (Burger, 1998). Snowmobile noise may also impinge upon private homeowners, whose quality of life could be disrupted and devalued.
Extent to which threat is currently regulated or otherwise managed	Many states have instituted safety regulations regarding the use of jet skis and other personal recreation vehicles, however, noise in and of itself is often not regulated. Local communities may implement local noise ordinances for jet skis, however, the extent of this type of regulation in the state of New Jersey is unknown.
Barriers to restoration	Lack of knowledge: More research is needed on the impacts of noise in coastal and oceanic environments to determine what actions are necessary to preserve the ecological health and integrity of affected species.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	L
Small business industry	L
Transportation	M (Commercial shipping activity causing underwater noise)
Residential	N/A
Agriculture	N/A

Issue: (Boat-Recreational) Noise
Author: Dobkowski-Joy
Version: 12/28/99

Recreation	H (Jet Ski, Snowmobile and ATV use)
Resource extraction	L (Noise caused by air jet use for oil extraction activities- probably not a factor off the coast of NJ)
Government	M (Scientific experiments utilizing acoustical measurements)
Natural sources/processes	L
Orphan contaminated sites	N/A
Diffuse Sources	
Sediment sinks	N/A
Soil sinks	N/A
Non-local air sources incl. deposition	N/A
Biota sinks	N/A
	Table compiled on 12/28/99 by Aleksandra Dobkowski-Joy of the US EPA Region II.

References

Bluewater Network Website, Accessed 12/18/99. (www.earthisland.org/bw/jetskifacts.shtml/) *Jet Ski Fact Sheet*.

Burger, J. 1998. *Attitudes about recreation, environmental problems, and estuarine health along the New Jersey shoreline, USA.* Springer-Verlag, Inc., Env. Mngt. 22:869-876.

Burger, J. 1998. *Effects of motorboats and personal watercraft on flight behavior over a colony of common terns.* Nelson Biological Laboratories, Rutgers University.

Holmes, R. 1997. *Noises Off.* New Scientist, Vol. 153 No. 2071. Pp.30-33.

Nelson, C. 1998. *Jet Skis Suck.* In "Making Waves", Surfrider Foundation June/July, 1998. Accessible on the web at www.surfrider.com/makingwaves3/jetski6.htm .

Natural Resources Defense Fund. *Proposed undersea noise tests threaten marine life.* NRDC website, accessed on 12/28/99. www.nrdc.org/status/ocnoissr.html .

New Jersey Marine Mammal Stranding Center website. (www.mmsc.org/index1.html) . Accessed on 12/28/99.

Sehgal, R. 12/12/1995. *Deaf Students' research shows noise pollution could be harmful to marine mammals.* Office of University Communications, University of Connecticut at Storrs.

Issue: Off-Road Vehicles (ORV)
Author: Buchanan
Version: 10/02

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Stressor:
Off-road Vehicles (ORV)

Issue Summary: Off-road vehicle (ORV) use was examined to determine the impacts of recreational activities on the land and waterscape. Impacts of off-road vehicles include accelerated soil compaction and erosion, pollution of water and air, noise, destruction of vegetation, direct harassment of wild animals and loss of wildlife habitat. Usage of off-road vehicles appears to be increasing on a national basis and may be increasing in NJ.

Approximately 343,000 acres of public lands (i.e., state park, forest and wilderness land) was estimated as having been damaged in NJ. The magnitude of impacts on private lands is not known. Overall, this stressor was ranked as low/moderate, due to the limited scale of potential/observed impacts on a statewide basis. Impacts are probably more severe on sensitive ecosystems including wetlands and streams, however, specific quantification is not possible at this time. Additional data is needed to better assess the magnitude and severity of the impacts of motorized recreation on NJ's ecosystems. DEP enforcement efforts and a new policy directive (2002) are expected to reduce impacts on public lands.

Severity: Low to Moderate. Overall impact on the state's ecosystems is expected to be low. Moderate impact is expected on those ecosystems where ORVs are extensively used (e.g., forests and parks).

Frequency: 3 to 4. It was estimated that the frequency of impacts ranged from "occasional" to "often and continuing".

Magnitude: 1 to 2. On a statewide basis, no more than 10% of an ecosystem was estimated to have been impacted.

Uncertainty: Moderate. Information on impacts is fairly well characterized; limited data on impacts and extent of damage in New Jersey is available.

Trend: Same. Although ORV use is increasing in NJ and the nation, recent policy changes and enforcement are expected to limit or reduce impacts on NJ's public lands. No data was readily available on the trend of impacts on other (e.g., federal, private) lands.

Potential for Catastrophic Impacts: Low

Introduction

In New Jersey, the term "off road vehicle" refers to a broad array of vehicles now in use by the public (NJDEP, 2002):
Any motorized vehicle with two or more wheels or tracks that is capable of being operated off of regularly improved and maintained roads shall be classified as an ORV. This includes all pickup trucks, sport utility vehicles, motor cycles, dirt bikes, all terrain vehicles and snowmobiles.
Class I ORVs include all vehicles that are licensed, registered, insured and inspected as required to legally operate on any road or highway of the State designated for vehicle traffic.
Class II ORVs includes any vehicle lacking one or more of the criteria needed for operation on any road or highway designated for vehicle traffic. Class II ORVs may be operated on public lands only with a special permit or on private property with the permission of the landowner.

Issue: Off-Road Vehicles (ORV)
Author: Buchanan
Version: 10/02
Impacts from ORVs include accelerated soil compaction and erosion, pollution of water and air, noise, destruction of vegetation, direct harassment of wild animals and loss of wildlife habitat (Noss & Peters, 1995). Limited use of all-terrain vehicles (ATVs) were found to impact wetland vegetation, with heavy usage impacts (lower stem height and productivity) still discernable a year later (Hannaford & Resh, 1999). Other impacts include soil rutting and displacement, tree scarring, root exposure and changes in plant composition (e.g., by allowing introduction of invasive plant species) (National Park Service, 2000).

Approximately 569,000 ATVs, 152,000 dirt bikes, and 136,000 snowmobiles were sold in the U.S. in 1999, as compared to 77,000 dirt bikes and 78,000 snowmobiles in 1990 (Clifford, 2000).
ORV users have increased from 19.4 million in 1983 to 27.9 million in 1995 (43.8% increase; Curtis, 2000).

In an attempt to reduce impacts of ORVs, the U.S. Forest Service and Bureau of Land Management proposed limiting the use of ATVs and other ORVs to existing roads and trails on 16 million acres of western public land (Curtis, 2000). However, critics say that enforcement is a problem, which limits the usefulness of the proposal.

There are also conflicts between recreational users, especially motorized versus non-motorized users. Actions that cause conflicts include:
Excessive speed and thoughtlessness
Resentment towards users who are faster or more mechanized than the offended party
Disturbing the peace and solitude that the offended party was expecting, and
Damage to the resource (e.g., causing erosion, ruts, and crushed vegetation) leading to the alienation of other users. (Outdoor Recreational Council, 2000)

New Jersey

Reports of habitat and vegetation destruction in New Jersey include illegal ATV use in State Forests, wetlands, and wildlife refuges. From January through September 2002, DEP conservation officers and park rangers have issued more than 1,400 summonses against individuals participating in illegal ORV activities, resulting in fines of up to $1,000 per violation. A total of 67 vehicles were impounded over the same time period. Approximately 343,000 acres of state park, forest and wilderness land was estimated as having been damaged. In highly urbanized NJ, the opportunities and amount of space for ORV use is limited. This often results in the illegal use of ORVs where the operator trespasses on private land (e.g., rights of way, open fields) or operates on public lands where motorized vehicles are prohibited. No data was readily available on the extent and severity of ORV damage on private or federal land.

Current Policy (NJDEP, 2002): "The use of ORVs shall be prohibited on lands owned, managed, maintained or under the jurisdiction of the Department, including any and all lands held jointly with any other party ("public lands"). There are certain limited exceptions to this general policy. On public lands, Class I ORVs shall only be operated on highways and roads, and only if in addition, the ORV is operated in accordance with Title 39 and the highway or road is designed and marked by the State for such operation. On public lands, Class II ORVs shall only be operated in areas designated and marked by the State for such operation and with a special use permit issued by the Department of Environmental Protection."

NJ has one park for off-road vehicles located in the Pine Barrens in Chatsworth and operated by a non-profit organization. The land is leased from the New Jersey Conservation Foundation and the 265-acre park is "dedicated to building, operating and maintaining safe and legal facilities for the operation of off-road vehicles" (NJORVP, Inc.). Another site, focused largely on kids, is the Egg Harbor Township Police Athletic League in Atlantic County. They use an abandoned sand pit of less than 30 acres (Tracy, 2002). Operations such as this potentially reduce impacts by focusing activity to one area and reducing use in other areas/habitats.

The 2002 policy directive indicated that DEP's Division of Natural and Historic Resources will work to develop appropriate recreational areas for lawful ORV users, with the goal of having two new such facilities in operation by 2005. No current state park, wildlife management area or other environmentally sensitive area will be considered during the selection process.

Issue: Off-Road Vehicles (ORV)
Author: Buchanan
Version: 10/02
Statewide Analysis of Threat Threat = Off-Road Vehicles

Ecosystem	**Severity/Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	2	3	1	6
Marine Waters	2	3	1	6
Wetlands	3	4	1	12
Forests	3	4	2	24
Grasslands	3	4	1	12
			Total Score	60
			Average Score (Total ÷ 5)	12

References:

Clifford, H. 2000. Whose forest is it, anyway? www.businessweek.com/2000/00_49/b3710210.htm

Curtis, S. 2000. All-terrain destruction, Almost everyone agrees, ATVs need to be controlled – but how? www.emagazine.com/may-june_2000/0500curr_atv.html.

Hannaford, M.J., V. H. Resh. 1999. Impact of all-terrain vehicles (ATVs) on pickleweed (Salicornia virginica L.) in a San Francisco Bay wetland. Wetlands Ecol. Manag. 7(4):225-233.

National Park Service. 2000. Final Off-Road Vehicle Management Plan, Supplemental Environmental Impact Statement, Big Cypress National Preserve, Florida.

NJDEP. 2002. DEP Commissioner Campbell Announces Off-Road Vehicle Policy. Press Release, October 2, 2002. www.state.nj.us/dep/newsrel/releases/02_0095.htm.

NJDEP. 2002. Policy Directive 2002-001. Off-Road Vehicle Use. October 4, 2002. www.state.nj.us/dep/newsrel/releases/orvpolicy.htm.

New Jersey Off-Road Vehicle Park, Inc. (NJOVRP, Inc.). Chatsworth, NJ. www.njorvp.org/info/.

Noss, R., and R.L. Peters. 1995. Endangered Ecosystems: A status report on America's vanishing habitat and wildlife. Appendix A: Threats to U.S. Ecosystems. www.defenders.org/pubs/eco09.html.

Outdoor Recreational Council of British Columbia. 2000. Examining a trail strategy for BC from the demand perspective. Vancouver, BC. www.luco.gov.bc.ca/trancan/orc.htm.

Tracy, C. 2002. Personal Communication. NJDEP, Division of Parks & Forestry.

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Overharvesting (Marine)**
Description of stressor	Overharvesting of Natural Resources Fisheries and Wildlife resources are exposed to a great deal of environmental stresses that can create an impact in the health and function of the ecosystems. Overharvesting of these natural resources degrades the ecosystem and decreases the habitat of some marine life. An example of such would be the overharvesting by the commercial fisheries, which can affect the marine life of blue crabs, eels and horseshoe crabs. The eggs of the horseshoe crabs are a source of energy for the migratory birds in the shoreline of NJ. The impact of the overharvesting will be discuss as following by presenting its impact in the Horseshoe Crab (*Limulus polyphemus*) A.K.A. King Crab, Horsefoot Crab. Horseshoe Crabs are anthropods and are considered to be living fossils because their appearance has not changed since their origin over 300 million years ago. Horseshoe crabs have survived so long because they can go a year without eating and endure extreme temperatures. At one time, there were many species of horseshoe crabs, There are 4 species which survive today: 3 live along the shore lines of Southeast Asia; and the other species live along the Atlantic coast from Nova Scotia south to the Yucatan peninsula, (Mexico). The horseshoe crab gets its common name from the "U" of its shell, which is called a carapace, which is the color of sand or mud. This helps the animal blend in with sandy and muddy bottoms on which it lives. The horseshoe crab has 2 compound eyes on the top of their shells with a range of 3 feet. The eyes are used for locating mates. These crabs possess a dozen legs, the majority with claws, which they use to swim upside down in the ocean. They also possess a flap hiding 200 flattened gills to propel themselves. The gills are located on the underside of the abdomen and they are called book gills. The horseshoe crab gets oxygen from the water using their gills. The tail is long and is called a telson. The length of the tail helps the crab to flip over when lying upside down on its body. This is important because when a horseshoe crab lies upside down for al long period of time, it can die. Horseshoe crabs grow by molting or shedding their shell. Molting occurs several times during the first two years and once a year afterwards. Molting occurs 16-17 times over a period of 9 to 11 years before sexual maturity and once mature it is believed to no long molt. These crabs emerge 25% larger after each molt. A horseshoe crab's live span is about 18 years of age.

	Horseshoe crabs migrate offshore in the winter and bury themselves in the mud/sand. An unknown signal triggers the horseshoe crab to move inland during the Spring and Summer. Spawning usually begins in late May when large numbers of adults move onto beaches to mate and lay eggs. The peak in spawning coincides with the full moon and evening spring tides. Adults prefer beach areas within bays and coves, which are protected from rough water. The female will lay about 100 green eggs, in clusters, in a shallow hole in the sand which she digs along the beach between high and low tide. Females which are larger in size than males will return on successive tides to lay more eggs. Females can produce about 88,000 eggs per year. Egg development usually takes about a month. Once hatched, larvae usually swim around I the shallow intertidal areas near the beaches where they were spawned until they settle to the bottom and molt. Horseshoe crab's nutrition consists of worms, mollusks, clams, skittles and dead fish. Since the horseshoe crab does not have jaws it uses their bristles to crush the food as it moves its legs. This means that a horseshoe crab can only eat while it walks along the bottom. Despite the horseshoe crab's physical appearance of a spinney shell, spiked tail, and clawed feet, they are harmless.
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	The impacts considered are habitat/ecosystem health and ecosystem function. The horseshoe crab eggs help to maintain a healthy ecosystem by being a source of food for migratory shore birds and other birds which include but are not limited to: Red Knots, sanderlings, ruddy turnstones, sand pipers, gulls, song sparrows, grackles, mourning doves and pigeons. Other animals that benefit from horseshoe crab eggs as a source of food are raccoons, foxes, diamondback terrapins and moles. Horseshoe crab eggs and larvae are a preferred food of many invertebrates and finfish including all crab species, whelks, striped bass, white perch, American eels, killifish, silver perch, weakfish, kingfish, silversides, summer and winter flounder.
Key impacts selected (critical ecological effects)	Key impacts evaluated are depletion of the horseshoe crab population by the fishing industry, a decline in the migratory shorebirds, and the medical industry. For example: In the early 1950's, a scientist Frederick Bang discovered that the blue colored blood of the horseshoe crab contains special cells that help kill certain kinds of bacteria. When a crab receives a wound, the cells swarm to the area, form a clot and kill the invading bacterial. Bang was able to separate the formed clots in presence of bacteria. He called this substance Limulus amoebocyte lysate (LAL). Research shows that this blood is rare, yet beneficial, but costly ranging up to $15,000.00/quart. (1). This product is also a source of a medical compound critical to maintaining the safety of many drugs used in medical practice. LAL, is used by pharmaceutical and medical device manufacturers to test their products for the presence of endotoxin, a bacterial substance that can be fatal to humans. All injectable drug products and all medical devices (such as replacement hips and artificial hearts) implanted into humans must be safely tested for the presence of endotoxin.

	Certain properties of the shell have also been used in medical research. Chitin is the substance used, which is found in the shells or exoskeleton of the horseshoe crabs. Scientists consider this substance non-toxic and, biodegradable which when processed is called chitosan. Chitin is found in contact lenses, skin creams, and hair sprays. It can also be used to remove lead and other harmful metals that may be dissolved in drinking water, and clean certain chemicals from wastewater. In addition it is known to fight against fat when added to food. It has the ability to bind with fats and then pass them through and out of the body without being digested. Many of these products are under development in the United States.
Exposure Assessment	
Exposure routes and pathways considered	NA
Population(s)/ecosystem(s) exposed statewide	In order to maintain the ecosystem of the horseshoe crab population, on November 17, 1997 the state governments of New Jersey, Delaware, Maryland and Virginia have agreed to commit resources to develop a Fishery Management Plan for the horseshoe crab. For the first time, the Atlantic States, which includes New Jersey will impose restrictions on the landings of horseshoe crabs and close the federal waters in a 30-mile radius from the mouth of the Delaware Bay to trawling for horseshoe crabs. The Atlantic States Marine Fisheries Commissions Horseshoe Crab Management Board (ASMFC-HCMB) recommended to the National Marine Fishery Services, which has jurisdiction from 3-200 miles off shore, establish an off shore horseshoe crab sanctuary (no harvest allowed within a 30 mile radius off the mouth of the Delaware Bay). New Jersey's restrictions have shown a decline in horseshoe crab harvesting from 606,583 in 1996 to 241,000 in 1998.
Quantification of exposure levels statewide	Restricted to the areas of the New Jersey between Fortesque in Cumberland County and Norbury's Landing in Cape May County.
Specific population(s) at increased risk	Delaware Bay horseshoe crab population and the migrating shorebirds as stated above.
Quantification of exposure levels to population(s) at increased risk	25% state cap for all fisheries
Dose/Impact-Response Assessment	NA
Quantitative impact-assessment employed	50% reduction in harvests
Risk Characterization	

Issue: Overharvesting (marine)
Author: Santiago/Ezze/Dobi
Version: 07/25/00

Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)	Females produce 88,000 eggs per year.	Score=
Assessment of severity/irreversibility 5 – Lifeless ecosystems or fundamental change; Irreversible 4 – Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 – Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 – Ecosystem exposed but structure and function hardly affected 1 – No detectable exposure		3
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 – Often and increasing 4 – Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Often and continuing in marine waters (4) and unlikely in other ecosystems.	3

Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- the State/population impacted	A female horseshoe crab can produce approx. 88,000 eggs per year. Egg development usually takes about a month. She will lie out approximately 100 green eggs in a cluster in a shallow hole in the sand, which she digs along, between high and low tide	2
	Total	18
Assessment of uncertainties in this assessment (H,M,L) and brief description	Moderate uncertainty due to limited data on the horseshoe crab population within NJ. New Jersey's Near Shore Recreational Fisheries Resources Survey is being used as an indicator of horseshoe crab relative abundance based on their sampling design and consistency (ASMFC, 1998). Because this survey is not designed specifically to sample horseshoe crabs, and the efficiency of capture for horseshoe crabs is not known for this survey, the data collected is not sensitive to collect trend information on horseshoe crab abundance. However this survey is consistent over time and is the most appropriate and reliable indicator of horseshoe crabs abundance trends.	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	High –Data Gaps: Research needs to be developed in NJ to establish the magnitude of this impact. NJ DEP researchers are currently gathering data to be able to quantify the extent of the horseshoe crab's existence in NJ between Fortesque in Cumberland County and Norbury's Landing in Cape May County.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, !, =, ≡; where + is improvement), and brief description.	(+)-The potential for change in the underlying risk from this stressor is positive, due to the expected reduction in the constant and consistent overharvesting of the horseshoe crab. This includes the Federal horseshoe crab reserve, and the ASMFC-Horseshoe Crab Management Board agreement between New Jersey, Delaware, Maryland and Virginia to reduce the commercial harvesting of horseshoe crabs. Furthermore, New Jersey's Governor Whitman has expanded the commitment by pledging a contribution of $50,000.00 toward research that will provide the necessary data to accurately access the status of the horseshoe crab population and the impact on the migratory shorebirds.	
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	M: Extensive commercial harvesting of horseshoe crabs (e.g., used as bait to catch conch) has depleted the population, resulting in a reduction in the numbers of eggs available to feed migratory birds. Recent efforts to protect the population may have reduced the potential for catastrophic impacts. However, the threat to the horseshoe crab population and the food chain that it feeds (e.g., migratory birds) remains; additional data and monitoring are needed to determine the short and long-term impacts and viability of these populations.	
Link to other Work Groups (e.g., socioeconomic impacts)	A socio-economical impact could result from the physical transformation of land/waterscape such as beach erosion. Such erosion can contribute to the demise of the horseshoe crab population, which can result in a decrease of eco-tourism.	

	Eco-tourism is a very important element of economy in NJ and is dependent on the abundance and health of the ecosystem. In 1988 over 90,000.00 bird watchers spent $5.4 million in Cape May alone to watch the interaction between spawning horseshoe crabs and migrating shorebirds. In 1996, in NJ, wildlife watchers spend between 9 and 12 days per year away from home watching wildlife (US Bureau of Census and USFWS, 1998). Total expenditures in 1996 for this purpose equaled $639,992,000.00 (USFWS, 1998). The economic impact resulting from expenditures of such, between NJ and Delaware, in 1996 was the creation of 15,127 jobs and the generation of a total household –income of $399 million (USFWS, 1998). In NJ horseshoe crabs are the primary bait for the American eel and conch fisheries. In 1997, American eel and conch harvesters used an average of 4,005 and 22,654 horseshoe crabs per season per harvester (Munson, 1998). In NJ conch and American eel harvesters harvest their own bait, supplying 18 to 65 % of their bait needs… only 9% of the fishing income is attributable to the direct sell of horseshoe crabs, an average of 58 % of the eel and conch fishing income depends on using horseshoe crab as bait. (Munson, 1998) In 1996, the commercial harvest of horseshoe crabs was estimated to be a 1.5 million-dollar industry. Horseshoe crabs are vital to medical research and pharmaceutical products. For example, bleeding 250,000 horseshoe crabs per year generates a revenue of $200.00 per crab for biomedical industry because the LAL (substance extracted from blood) is currently estimated to be 50 million dollars per year (ASMFC, 1998).
Extent to which threat is currently regulated or otherwise managed	Regulations/ Restrictions began in 1997. In NJ harvest requires a horseshoe crab permit and mandatory monthly reporting. However, there are some exceptions if other specific types of permits have been issued, such as a miniature fyke, lobster, or fish pot license and written verification that horseshoe crabs were obtained from a legal source. Harvest by any other means than by hand (i.e., trawling or dredging) is prohibited. There is a limitation on the horseshoe crab harvest season, which runs from April 1 to August 15. No harvest is allowed from the beaches and the shoreline adjacent waters and uplands within 1000 feet of mean high water along the Delaware Bay. However, hand harvest is allowed in areas other that those mentioned above, two days a week (Tuesday and Thursday) (Himchak, pers. Comm., 1997). In 2001, the National Marine Fisheries (NMFS) designated an area closed to fishing for horseshoe crabs in federal waters in an arc at the mouth of the Delaware Bay, creating a horseshoe crab sanctuary (see Figure 1).
Barriers to restoration	Commercial fishing pressure.

Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	NA
Small business industry	H (Commercial Fishing)
Transportation	NA
Residential	NA

Issue: Overharvesting (marine)
Author: Santiago/Ezze/Dobi
Version: 07/25/00

Agricultural	H (Fisheries)
Recreation	M (Human Disruption)
Resource extraction	H (Over use in Medical Research)
Government	NA
Natural sources/processes	NA
Orphan contaminated sites	NA
Diffuse Sources	
Sediment sinks	NA
Soil sinks	NA
Non-local air sources incl. Deposition	NA
Biota sinks	NA

Summary Statement:

Overharvesting of natural resources impacts target and non-target populations as well as the habitat of these species. An example is the overharvesting of the horseshoe crab by the commercial fishing industry. Horseshoe crabs are valuable components of the marine and estuarine ecosystems. Their eggs provide a valuable source of food and energy for migratory birds such as red knots, sanderlings, ruddy turnstones, sand pipers, and other species. Aquatic invertebrates and fish also feed on the horseshoe crab eggs. Depletion of the horseshoe crab population is a direct result of overharvesting of the resource. This decline may be a factor in the decreasing numbers of migratory shorebirds observed along Delaware Bay. The National Marine Fisheries Service has recently established a horseshoe crab sanctuary off the mouth of Delaware Bay (see Figure 1) in order to protect the resource.

Issue: Overharvesting (marine)
Author: Santiago/Ezze/Dobi
Version: 07/25/00

Statewide Analysis of Threat

Threat = Overharvesting of Horseshoe crabs

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	NA	NA	NA	NA
Marine Waters	3	5	5	75
Wetlands	2	3	3	18
Forests	NA	NA	NA	NA
Grasslands	NA	NA	NA	NA
			Total Score	93
			Average Score	18.6

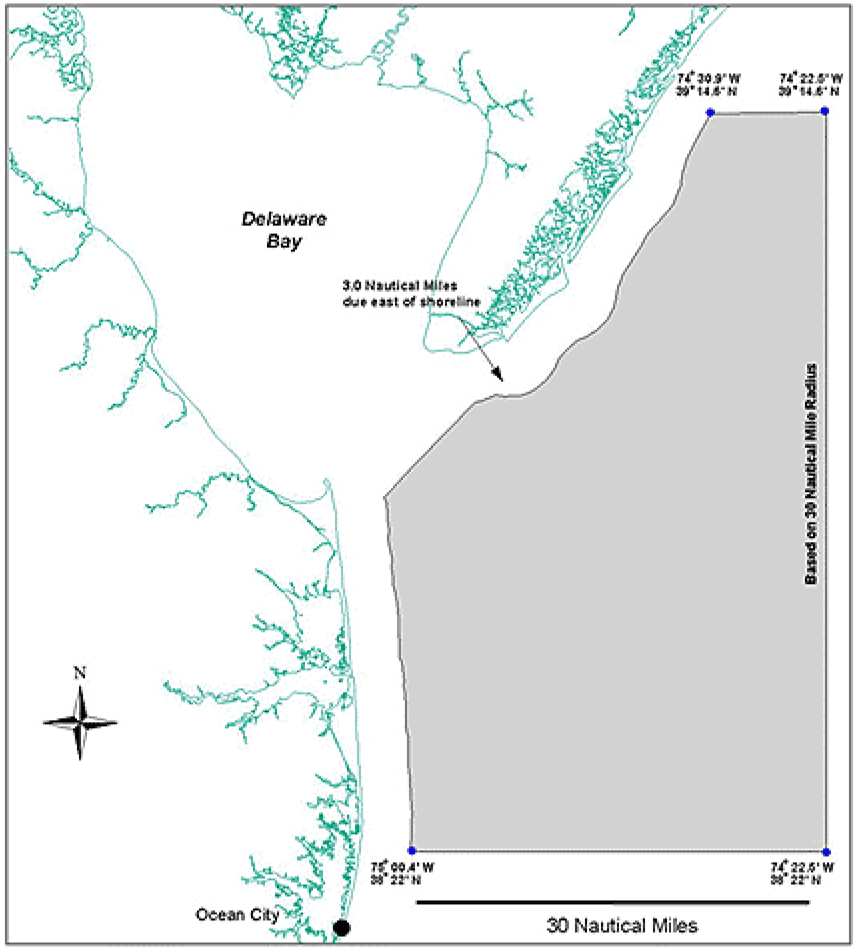
Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	NA	M	L	NA	NA
Passaic	NA	M	L	NA	NA
Raritan	NA	M	L	NA	NA
Atlantic	NA	H	H	NA	NA
Lower Delaware	NA	H	H	NA	NA
Region/Watershed (secondary)					
Urban	NA	L	L	NA	NA
Suburban	NA	L	L	NA	NA
Rural	NA	L	L	NA	NA

H=high, M=medium, L=low, NA = not applicable

Figure 1. Carl N. Schuster Jr. Horseshoe Crab Reserve (NOAA, 2001)

Issue: Overharvesting (marine)
Author: Santiago/Ezze/Dobi
Version: 07/25/00



References Cited:

Animal & Habitat Aquafacts, horseshoe crab. Http://www.mysticaquarium.org/animals/aquafacts

Animals-Horseshoe Crab: Horseshoe Crab living fossil. Http://www.aqua.org/org/animals/species/prhcrab.html

Atlantic Horseshoe Crab (Limulus Polyphemus). (2/26/99) Horseshoe Crab Facts. 1-5p. http://www.dnr.state.md.us/fisheries/education/horseshoe/horseshoefacts.html.

Atlantic States Marine Fisheries Commission. 1999. Horseshoe Crab Stock Assessment Report for Peer Review, Stock Assessment Report # 98-01 Supplement.

Beard, D.P. Audubon News: "National Audubon Society Statement on Horseshoe Crab Landing Limits" http://www.audubon. org/news/release/horseshoe.html

Burger, J. 1997. Heavy metals in the eggs and muscle of horseshoe crab (Limulus polyphemus) from

Delaware Bay. Environmental Monitoring and Assessment 46:279-287.

Himchak. P. 1997. Fisheries Biologist. Division of Marine Fisheries, New Jersey Department of Environmental Protection. Trenton, New Jersey.

Horseshoe Crabs-The Ancient Mariners. http://www.beach-net.com/horseshoe/bayhorsecrab.html

Lawlor, E.P.1992. Discover Nature at the shore. Stackpole Books. Harrisburg, PA

Lippson, A.J. & R.L. Lippson. 1994. Life in the Chesapeake Bay. John Hopkins University Press. Baltimore, MD.

Munson, R.E. 1998. Bait needs of the eel and conch fisheries in New Jersey and Delaware as determined from questionnaires filled out by commercial fisherman in those fisheries. Delaware Bay Watermen's Association. Newport, New Jersey.

NOAA. 2001. NOAA Fisheries Closes Area to Fishing for Horseshoe Crabs. NOAA 2001-R104, Press Release dated 2/5/01.

Proceedings of the Horseshoe Crab Forum Status of the Resource. February 23, 1996. University of Delaware. Hugh R. Sharp Campus, Lewes, Delaware.

The Assateague Naturalist, Horseshoe Crab. http://www.assateague.com/horsesho.html

The Horseshoe Crab or King Crab. http://www.globalclassroom.org/hshoe.html

Tolme P. Star Ledger "Luck may be changing for horseshoe crab through restricted Harvest". February 6, 2000.

U.S Bureau of Census and U.S Fish and Wildlife Service. 1998. 1996 National survey of fishing, hunting and wildlife-associated recreation. US Bureau of Census and US Fish and Wildlife Service. Washington, D.C.

.

US Fish and Wildlife Service. 1998. 1996 national and state economic impacts of wildlife watching. US Fish and Wildlife Service, Washington, DC.

Wegg, Patti.1998. Re: Wonderful! Let's visit'' Kabutogani (Horseshoe Crab). http://www.kidlink.org

Issue: Ozone (Ground Level)
Author: Valerie Thomas
Version: 01/09/01

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Ozone (Ground Level)**
Description of stressor	Ozone (O_3) is not typically emitted directly into the atmosphere but results mostly from a series of reactions between nitrogen oxides and volatile organic compounds in the presence of sunlight. As a result, exposure to high concentrations of ozone is a problem on hot sunny summer days and the vast majority of exceedances of the NAAQS occur between May 15 and August 31. Ozone is only one of a class of compounds, known collectively as photochemical oxidants, that result from such reactions. The mixture of pollutants that forms on high ozone days is commonly referred to as "smog."
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Ozone is the gaseous pollutant most injurious to agricultural crops, trees, and native vegetation. Exposure of vegetation to ozone can inhibit photosynthesis, alter carbon (carbohydrate) allocation, and interfere with mycorrhizal formation in tree roots. Disruption of the important physiological processes of photosynthesis and carbon allocation can suppress the growth of crops, trees, shrubs, and herbaceous vegetation by decreasing their capacity to form the carbon (energy) compounds needed for growth and maintenance and their ability to absorb the water and mineral nutrients that they require from the soil. In addition, loss of vigor impairs the ability of trees and crops to reproduce and increases their susceptibility to insects and pathogens (US EPA, 1996).
Key impacts selected (critical ecological effects)	Damage to vegetation, especially in urban areas and in agriculture.
Exposure Assessment	
Exposure routes and pathways considered	Direct air exposure.
Population(s)/ecosystem(s) exposed statewide	All ecosystems statewide are exposed.
Quantification of exposure levels statewide	In the 1980s, the number of days that the 0.08 ppm ozone standard was exceeded in New Jersey ranged from 18 to 60 per year. In the 1990s, the number of exceedance days has dropped to 6 to 26 (Held, 2000).
Specific population(s) at increased risk	Agroecosystems are viewed as being at increased risk because of the economic impact of reduced growth. Urban vegetation is at increased risk because urban exposures are somewhat higher than regional exposures. .
Quantification of exposure levels to population(s) at increased risk	
Dose/Impact-Response Assessment	Some effects occur with only a few exposures above 0.08 ppm. At least 50% of the species and cultivars tested exhibit a 10% yield loss at 7-h seasonal mean ozone concentrations of 0.05 ppm or less (US EPA, 1996). New Jersey ozone levels are unlikely to have a visible impact on forest ecosystems, although ozone exposure may adversely affect individual trees such as eastern white pine and black cherry. Ozone exposures are, however, more

	likely to be having an impact on agricultural crops and on urban vegetation.	
Quantitative impact-assessment employed		
Risk Characterization		
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	While agricultural crops and urban vegetation in New Jersey may be affected by ozone, the structure and function of these ecosystems it not much affected (2).	2
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Because ozone exposure is continuing, any effects that are occurring are often and continuing (4)	4

Issue: Ozone (Ground Level)
Author: Valerie Thomas
Version: 01/09/01

Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	Less the 5% of the state's ecosystems are likely to be significantly impacted overall (1). Perhaps 10 – 25% of New Jersey agricultural crops might have somewhat reduced productivity due to ozone exposure (3), and perhaps 10 – 25% of vegetation in urban ecosystems might be experiencing reduced growth due to ozone exposure (3)	1
	Total	8
Assessment of uncertainties in this assessment (H,M,L) and brief description	L.	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	L	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, ! , =, ≡; where + is improvement), and brief description.	+ Precursor emissions should decrease as a result of the actions contained in New Jersey's State Implementation Plan but this will not be enough to meet the standard. However, it is unknown at this time whether the levels of precursors originating from out of state will decline.	
Potential for catastrophic impacts (H,M,L) and brief description	L	
Link to other Work Groups (e.g., socioeconomic impacts)	The Human Health impacts of ozone exposure are significant.	
Extent to which threat is currently regulated or otherwise managed	Ozone is regulated by the US Clean Air Act.	
Barriers to restoration		
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources		
NJ Primary Sources		
Large business/industry	H – NOx and hydrocarbon emissions.	
Small business industry	M	
Transportation	H – NOx and hydrocarbon emissions	
Residential	M	
Agriculture		
Recreation	(?L-M barbecues, 2-stroke engines, marine craft)	
Resource extraction		

Issue: Ozone (Ground Level)
Author: Valerie Thomas
Version: 01/09/01

Government	
Natural sources/processes	
Orphan contaminated sites	
Diffuse Sources	
Sediment sinks	
Soil sinks	
Non-local air sources incl. deposition	
Biota sinks	

Statewide Analysis of Threat Threat =Ozone

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	1	0.1	1	0.1
Marine Waters	1	0.1	1	0.1
Wetlands	2	4	1	8
Forests	2	4	1	8
Grasslands	2	4	1	8
			Total Score	24.2
			Average Score (Total ÷ 8)	4.84

Risk by Watershed Management Region

THREAT = Ozone	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	NA	NA	L	L	L
Passaic	NA	NA	L	L	L
Raritan	NA	NA	L	L	L
Atlantic	NA	NA	L	L	L
Lower Delaware	NA	NA	L	L	L

Region/Watershed (secondary)					
Urban	NA	NA	L	L	L
Suburban	NA	NA	L	L	L
Rural	NA	NA	L	L	L

H=high, M=medium, L=low, NA = not applicable

References

Held, Joann. Ozone Health Risk Assessment. Human Health Technical Working Group. NJ Comparative Risk Project. June 15, 2000.

US EPA. Ozone Air Quality Criteria Document. Executive Summary. June 1996.

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	**Pesticides - Historical Use**
Stressor	Pesticides - Historical Use DDT and Chlordane as examples of Chlorinated Pesticides on the United Nations' Persistent Organic Pollutants List
Description of stressor	All chlorinated pesticides tend to persist in the environment and bind tightly to soil particles. Some examples of chlorinated pesticides are DDT (dichlorodiphenyltrichloroethane) and Chlordane. World War II saw the first widespread use of synthetic pesticides such as DDT. DDT was first used during the war for crop protection and for protecting troops from typhus (by controlling lice) and malaria (by controlling mosquitoes). DDT use greatly expanded in the 1950's because it is not soluble in water, has a long half-life (10-35 years), is persistent, has a high-contact toxicity, and is inexpensive to manufacture. DDT was the most widely used agricultural insecticide in the world from 1946 to 1972. Total world production of DDT during this period has been estimated from 2.8 million tons to more than 3 million tons. In New Jersey, DDT was widely used to control mosquitoes and a broad range of insect pests on vegetables and fruits. DDT was also used for the control of household pests. In 1962, Rachel Carlson linked the use of DDT to the decline of songbirds and raptors such as the bald eagle and osprey. DDT and other chlorinated pesticides prevent eggshells from reaching their proper thickness, making them much more vulnerable to breaking during incubation. Since DDT is fat soluble, it was found in the tissues of many animal species, including fish, birds, and mammals. Certain insects were also developing resistance to DDT. This led to a ban on DDT use in the United States in 1972. Because DDT and the other chlorinated pesticides are so persistent in the environment, their residues are still detected and are still affecting the environment. DDT is a white, crystalline, tasteless, and almost odorless solid. DDT is now banned in 49 countries and severely restricted in 29. DDT creates a risk of harm to humans, animals, and the environment because it is designed to kill or otherwise adversely affect living organisms. Chlordane, a chlorinated pesticide banned for termite control since 1988 and banned for agricultural and residential use since 1983, is presently being found in the brain tissue of dead grackles in north and central New Jersey. Chlorinated pesticides are suspected of acting as endocrine disruptors causing effects such as the feminization of male birds, male and female reproductive problems in alligators, and the killing of thousands of marine mammals such as seals and dolphins due to immune system suppression. Chlordane was used in the United States from 1948 to 1988. Until 1983, chlordane was used as a pesticide on crops like corn and citrus and on home lawns and gardens. For the next five years, chlordane was used exclusively controlling termites. Chlordane is a manufactured chemical that consists of a mixture of many related chemicals, of which about 10 are major components. It is a thick liquid whose color ranges from colorless to amber. Chlordane also has a mild, irritating smell.
Stressor-specific impacts considered: Biological integrity	Organochlorine pesticides, including DDT, put a stress on biological integrity, biodiversity, habitat/ecosystem health, and proper ecosystem function.

Biodiversity Habitat/ecosystem health Ecosystem function	
Key impacts selected (critical ecological effects)	Impact of chlorinated pesticides on animal reproduction and on immune systems. Documented impacts of chlorinated pesticides on New Jersey fish and shellfish
Exposure Assessment	
Exposure routes and pathways considered	Though DDT and the other chlorinated pesticides can be absorbed by inhalation, or direct contact with the skin, oral exposure through the ingestion of contaminated foods is considered the most important exposure route. When DDT and the chlorinated pesticides are ingested, they are stored in an organism's fat cells because these compounds are fat-soluble. These pesticides and their metabolites work their way up the food chain until those species at the top of the food chain have many times the concentration of these compounds than do the organisms at the bottom. For example, in Lake Ontario, plankton were found to have a concentration of DDT of 0.01ppm wet weight while the Herring Gull (near the top of the food chain) had a DDT concentration of 6.30ppm wet weight, 630 times the concentration of the plankton.
Population(s)/ecosystem(s) exposed statewide	It is reported that worldwide levels of DDT and its degradation products have been declining over the past 25 years. Since DDT, chlordane, and the other chlorinated pesticides were used quite extensively, they are found all over the state. Because DDT is so stable, is not water-soluble, and likes to bind to soil, 50% of the DDT sprayed on a field can remain in the soil 10 to 35 years after application. DDD, a metabolite of DDT, has been shown to last as long as 190 years in soil, water, and sediment. DDT and the other chlorinated pesticides are transported into the environment through wind erosion, water erosion, and volatilization into the atmosphere, where they can travel long distances on air currents, returning to the ground by precipitation.
Quantification of exposure levels statewide	DDT, Chlordane, and other chlorinated pesticides were used extensively for a very broad range of insect control. Applications ranged from agricultural purposes to lawn and garden treatments, to termite control. Since chlorinated pesticides tend to persist for long periods, it is almost impossible to estimate how much of the population/ecosystem has been exposed. In addition, some countries still allow the use of chlorinated pesticides, which increases the exposure potential. DDT and its metabolites frequently are found in DEP agricultural soil samples throughout the state. Between 4% to 8% of these sample sites exceed the DEP residential cleanup criteria. DDT- related pesticides also are found in sediments of the Delaware River Estuary and New York-New Jersey Harbor.
Specific population(s) at increased risk	Species at the top of the food chain, especially piscivorous species, are the most vulnerable to chlorinated pesticides due to bioaccumulation. These species include raptors such as the osprey and bald eagle, fish such as bluefish and trout, and mammals such as bears and river otter.
Quantification of exposure levels to population(s) at increased risk	Bald eagles have been found to have 4-20ppm of DDE in their eggs, Peregrine Falcons have been found to have 1.8-29.3ppm DDE in their eggs. Trout have been shown to contain 1.10 ppm DDT. Clams and polychaete worms in the Atlantic Ocean off the Raritan River Estuary have been found to have 3.04ppb and 7.01ppb of total DDT respectively.
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	Various governmental agencies, including the NJ DEP, the Delaware River Basin Commission, the EPA, FDA, and the US Geological Survey have analyzed soil and water samples from NJ as well as tissue samples from species that reside in NJ. The presence of DDT, DDE, and DDD have been found in at least 337 or 1,416 National Priorities List sites identified by the Environmental Protection Agency. Chlordane was found in 171 of 1,416 NPL sites. For New Jersey,

	information was not readily available on the presence of DDT, DDE, DDD, or Chlordane in the surface water. Soil sampling has shown that DDT, DDE, and DDD are still present in the soil. Surface waters might also have DDT, DDE, and DDD present since they do not break down readily and bind tightly to the soil. Through direct spraying, runoff, and erosion, the chemicals might have bound to the particulate material in the water column and settled in the sediment.	
Risk Characterization		
Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score

Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	Since the use of DDT has been banned since 1972 and chlordane banned since 1988, the populations of impacted raptors such as the bald eagle and osprey have been increasing. However, since these compounds and their metabolites are so persistent in the environment, they are still affecting wildlife and ecosystems. Dead grackles and crows have been found near their roost trees with sizable concentrations of chlordane in their brain tissue. It is feared that low concentrations of chlorinated pesticides can act as endocrine disruptors, causing reproductive problems in birds, reptiles, and amphibians. In areas such as Pennsauken Creek, Chlordane was found in the sediment and in fish tissue. Restrictions have been placed on the fish and shellfish caught in some areas of New Jersey due to chlorinated pesticide levels found in them. In addition, since the use of chlorinated pesticides was so broad and abundant for such a long period, some of the target pests have developed a resistance.	3

Issue: Pesticides – Historical Use
Author: Rush/Meyer
Version: 03/12/01

Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	The frequency of negative effects depends on how much DDT, chlordane and other chlorinated pesticides were used in a particular area and whether they were used for agriculture, mosquito control, or residential use, since different doses were used for different applications. There may be more problems as more farmland is developed for residential use, exposing the environment to the pesticides that were lying undisturbed in the soil for years. Since chlorinated pesticides are semi-volatile, they may migrate to New Jersey from other areas. Erosion, runoff, and drift can lead to more of the contaminated soil ending up in the sediment of water bodies.	3
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State impacted 4- 25-50% of the State impacted 3- 10-25% of the State impacted 2- 5-10% of the State impacted 1- <5% of the State impacted	Chlorinated pesticides were used throughout New Jersey for mosquito control, agricultural use, and residential use. Though DDT has been banned since 1972 and chlordane has been banned since 1988, these pesticides and their residues are still found in soil and animal tissue samples throughout the state.	5
	Total	45
Assessment of uncertainties in this assessment (H,M,L) and brief description	H= It is unknown how pesticides currently in use and other pollutants affect surface and ground water in conjunction with the levels of chlorinated pesticides in New Jersey	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data	M=More research is needed to see if levels of DDT, chlordane, and other chlorinated pesticides and their metabolites found in NJ's environment are acting as endocrine disrupters on at-risk species in NJ. Much of the work concerning chlorinated pesticides has been done on species in other states. Other potential effects of chlorinated pesticides that	

needs)	should be investigated include immune suppression and abnormal nesting behavior (adversely affecting chick survival) in NJ gulls and terns. Migrating birds such as ducks and geese should be monitored for DDT and other pesticides by analyzing the wings of hunter-killed waterfowl. More testing needs to be done in New Jersey to see how many of the bodies of water in New Jersey have chlorinated pesticides found in the sediment, water column, and aquatic life. Also more testing needs to be done to see how many more contaminants are entering New Jersey's surface and ground water due to erosion and runoff of overturned soil from the urbanization of farmland.
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, ! , =, ≡; where + is improvement), and brief description.	++, DDT and other chlorinated pesticides will gradually breakdown over time. Since chlorinated pesticides are semi-volatile, there is the potential for these compounds to migrate from areas that still use these pesticides.
Potential for catastrophic impacts (H,M,L) and brief description	L= The build-up of chlorinated pesticides, such as DDT, in fish has lead to egg shell thinning in raptors like the bald eagle and osprey, thus leading to a decline in raptor populations. Raptors have been recovering since DDT and other chlorinated pesticides have been banned, but since these compounds are persistent in the environment, they will still affect wildlife for years to come.
Link to other Work Groups (e.g., socioeconomic impacts)	Socio-Economic The levels of chlorinated pesticides found in wildlife can affect the fishing industry as well as other industries associated with wildlife such as hunting and tourism. Human Health=DDT and other chlorinated pesticides have been detected in human tissue and breast milk, which can affect human health.
Extent to which threat is currently regulated or otherwise managed	In addition to total bans, the federal and New Jersey state governments regulate the levels of DDT, Chlordane, and other chlorinated pesticides permitted in drinking water and food. Federal and state governments also regulate levels of these pesticides in soil and sediment that trigger a cleanup.
Barriers to restoration	Since DDT and chlorinated pesticides are so persistent and pervasive in the environment, in many instances little can done except wait for them to breakdown. Since chlorinated pesticides are semivolatile, there is the potential of these compounds migrating from areas where they are still in use. The population/ecosystems will not fully recover until all chlorinated pesticide use is banned worldwide.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	L
Small business industry	L
Transportation	L
Residential	L
Agriculture	L
Recreation	L
Resource extraction	L
Government	L

Issue: Pesticides – Historical Use
Author: Rush/Meyer
Version: 03/12/01

Natural sources/processes	L
Orphan contaminated sites	L
Diffuse Sources	
Sediment sinks	H
Soil sinks	H
Non-local air sources incl. deposition	M
Biota sinks	H

DDT and other chlorinated pesticides have been banned in the United States due to their harmful affects on the population/ecosystem. Because of their chemical properties and widespread use for decades throughout New Jersey, they are persistent throughout the environment. They bioaccumulate in plants and the fatty tissues of wildlife, working their way up the food chain, until they affect the species at the top of the food chain. Historically, DDT and the other chlorinated pesticides caused the thinning of eggshells in many bird species, causing a decrease in their populations. Thanks to the ban on DDT, chlordane and other organochlorine pesticides, these species are recovering. However, there may be other affects such as endocrine disruption that may affect behavior and reproduction in many New Jersey species. Chlorinated pesticides are manufactured compounds that bind tightly to the soil and persist in the environment for long periods of time. Erosion, runoff, and direct application to the bodies of water in New Jersey have lead to adverse effects on the environment. Chlorinated pesticides bind with suspended solids in the water column and eventually become part of the sediment. Due to the high levels of chlorinated pesticides found in the fatty tissue of fish and shellfish, certain bodies of water have had restrictions placed on them. Since the ban of chlorinated pesticides in this country, the affects on the environment have been improving but it will take many more years to fully recover.

Issue: Pesticides – Historical Use
Author: Rush/Meyer
Version: 03/12/01

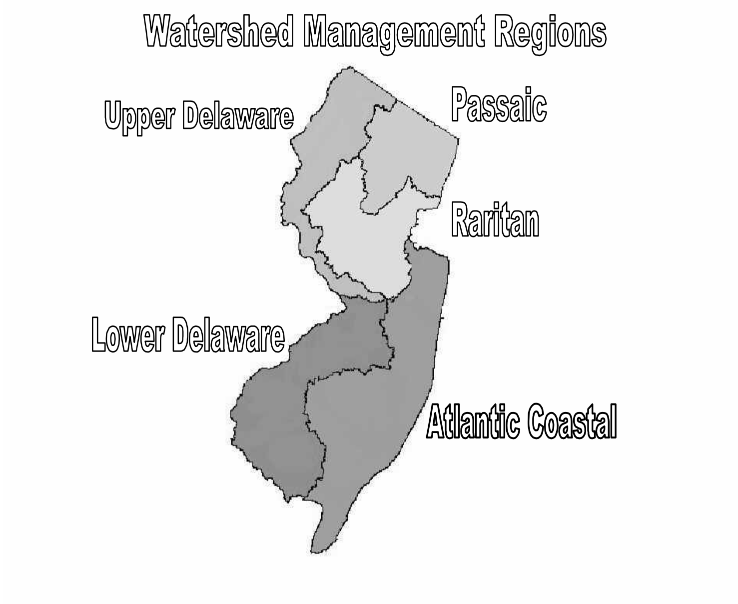
Statewide Analysis of Threat Threat = Historical Use Pesticides (DDT/Chlordane)

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score (S/I x F x M)**
Inland Waters	3	3	5	45
Marine Waters	3	3	5	45
Wetlands	3	3	5	45
Forests	3	2	5	30
Grasslands	3	3	5	45
			Total Score	210
			Average Score (total score ÷ 5)	42

Risk by Watershed Management Region

THREAT = Historical Use Pesticides Historical Use Pesticides	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	M	NA	M	L	M
Passaic	M	M	M	L	M
Raritan	M	M	M	L	M
Atlantic	M	M	M	L	M
Lower Delaware	M	M	M	L	M
Region/Watershed (secondary)					
Urban	L	L	L	L	L
Suburban	M	M	M	M	M
Rural	M	M	M	M	M

H=high, M=medium, L=low, NA = not applicable



References

NJ Divers, NJ Council of Diving Clubs, February, 2000

Regan, "Chlordane Lingers in NJ Lawns" Trenton Times, December 3, 2000

Schmitt and Bunk, "Persistent Environmental Contaminants in Fish and Wildlife", USGS, DRBC Report, 1998, Section 3.2.5, p. 30

World Wildlife Fund. January, 1999. "Hazards and Exposures Associated with DDT and Synthetic Pyrethroids used for Vector Control".

World Wildlife Fund. January, 1999. "Persistent Organic Pollutants: Hand-me-down Poisons That Threaten Wildlife and People", Issue Brief.

Internet Websites

www.biology.usgs.gov/s+t/noframd/u208.htm

www.worldwildlife.org/toxics/progareas/pop/pop_prnt.htm

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Pesticides – Present Use**
Description of stressors	Present Use Pesticides This template examines the ecological risk of pesticides that are currently used in New Jersey. Due to the numerous types and numbers of pesticides, only examples of typical or commonly used pesticides were selected for this assessment and include aquatic herbicides, carbamates, organophosphates, agricultural and household pesticides. The types of pesticides are discussed separately within the categories below and throughout the template. 1. **Aquatic Herbicides** (Elemental Copper, Copper Sulfate, Diquat, Endothall, Fluridone, and Glyphosate), Mosquito Larvicides (Methoprene and Temephos) 2. **Oxamyl** is a carbamate insecticide used on field crops, vegetables, fruits and ornamental plants to control a broad spectrum of insects, mites, ticks and roundworms. The majority of oxamyl is applied to apples, potatoes and tomatoes (USEPA, 1998). According to the USEPA (1999), about 800,000 pounds of oxamyl are used annually. Oxamyl may be applied directly onto plants or surface soil. Exposure to oxamyl will produce similar effects to the other carbamate compounds and is considered highly acutely toxic to birds and mammals. Chronic reproductive effects are also noted for birds and mammals. **Diazinon** is a broad-spectrum, organophosphate insecticide. As an organophosphate, it works as a cholinesterase inhibitor for all exposure pathways and durations. Its versatility lends to a wide variety of registered uses, including agricultural crops and residential turf and indoor and outdoor pests. Similar to other organophosphates, diazinon is available in various formulations. However, the granular form of diazinon was linked to incidents of wildlife mortality. Based on this information, the USEPA removed the granular form, along with diazinon use on golf courses and sod farms, from the list of registered uses in 1988. According to the USEPA (2000), over 13 million pounds of diazinon are introduced into the environment each year. The overwhelming use of diazinon has far-reaching ecological impacts, the most significant of which include wildlife mortality and surface water contamination. The USEPA (1999) has attributed 300 occurrences of wildlife mortality (primarily birds) to diazinon. These incidents range in size from a single bird to hundreds of birds. Diazinon is also highly toxic to beneficial insects, including honey bees, and fish and aquatic invertebrates. In addition to the adverse effects associated with the parent diazinon, terrestrial vertebrates are also exposed to degredates of diazinon, diazoxon and oxypyrimidine. **Resmethrin** is a broad-spectrum insecticide used to control insect pests in agriculture, households, stored products and mosquito control. Resmethrin is one of over 1000 insecticides that belong to a diverse class called the synthetic pyrethroids. The chemical structure of synthetic pyrethroids is based on the structure and activity of pyrethrum, an extract from Chrysanthemum plants. Although the synthetic pyrethroids are structurally similar to "natural" insecticides, they are engineered to have increased toxicity and persistence. Resmethrin, along with other synthetic pyrethroids including permethrin and sumithrin, are commonly used in mosquito control programs as adulticides. The recent outbreak of West Nile Virus in New York and New Jersey has raised many questions about the risk/benefit equation associated with the use of insecticides, specifically synthetic

	pyrethroids. 3. **Pesticides in surface and ground water**. Pesticides in surface and ground water have been detected in New Jersey and many other states. Surface waters are particularly vulnerable to pesticide contamination because runoff from cropland, forests, rangelands, golf courses, and lawns where pesticides are applied drains into streams, rivers, and lakes. Waste water discharges, atmospheric deposition, spills, and ground water inflow also contaminate surface waters. The most widely used pesticides in today's agriculture are the triazine (atrazine, cyanazine, and simazine), and acetanilide (alachlor, metolachlor, and propachlor) herbicides. Because these herbicides are readily soluble in water and have relatively low soil-sorption coefficient, they can be easily lost as surface runoff or by leaching into the ground water aquifer. In the Midwest, where these herbicides have been heavily used on corn and other field crops, high concentrations in streams and rivers draining agricultural lands have been detected in spring and early summer when applications are made. When pesticides are carried in runoff to surface waters, they can affect aquatic and animal life. Similarly, sufficient concentrations in drinking water may endanger human health. In New Jersey, as in many other places, streams and reservoirs supply the bulk of drinking water to urban/ suburban communities, while well water is the main source of drinking water in many rural areas. With increase in pesticide usage, there is a growing concern among New Jersey communities about the presence of pesticides in surface and ground water systems and the possible adverse effect they may have on human health and the aquatic ecosystem.
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	The following discussions deal with aquatic herbicides, mosquito larvicides, atrazine, oxamyl, diazinon, and resmethrin; the impacts can be generalized for the majority of current use insecticides & herbicides. 1. Aquatic herbicides and mosquito larvicides are purposefully applied to the waters of the State of New Jersey to provide a water resource of high quality and safety to residents, recreational users, sportsmen, and municipal water systems. These pesticides are introduced into the State's lakes, ponds, and wetlands primarily to control weeds and mosquito vectors maintaining a safe and healthy environment within the communities of the State. Aquatic herbicides in current use (21) are marked by relatively low acute toxicity indices to mammals, fish, and beneficial organisms (8 and Table 1). However, published risk assessment data frequently are based on the sensitivity of a few species taken to represent entire biological communities (22) and must be accepted with caution. For example, the ecological risk index presented in Table 1 is composed of sub-indices covering toxicity to two fish species, several bird species, and daphnia (8) and may not represent the potential impact of pesticide use environmental attributes of New Jersey aquatic systems. Surveys of published literature reveal the availability of a substantial volume of data on the acute toxicological effects of pesticides on non-target organisms. Lynch and Benbrook (8) point out that the research community is reasonably confident that the identification and study of acute toxicological properties of most commonly used pesticides have been achieved. NJ Bureau of Pesticide Compliance investigations of fish kills usually are initiated by a report of dead fish floating on the water surface a few days after an application of an aquatic herbicide. These investigations frequently conclude that mortality resulted indirectly from the depletion of dissolved oxygen by decaying plant materials and a misapplication of the herbicide. Unfortunately, kills of, and adverse chronic effects on, very young and early life stages of aquatic fauna resulting from pesticide applications are not easily observed and not reported to the Bureau of Pesticide Compliance. Similarly, applications of aquatic pesticides requiring high concentrations to produce acute lethal responses by aquatic fauna at dosages greater than instructed by the label and required to control the target pest would not be detected by on-site observations.

	Additionally, data documenting and available to evaluate sub-chronic and chronic effects on organ differentiation and development, immune system development and function, or neurological integrity and behavior of non-target organisms are scant (8). Early life stages of aquatic organisms can be expected to be more sensitive than later growth stages to deleterious effects of pesticides. Lynch and Benbrook (8) point out that only a small body of literature exists to identify those pesticides, which at sub-acute dosages, can reduce fish and bird populations through chronic and indirect mechanisms, such as: Reduction in the abundance and diversity of invertebrates, an important food source especially during avian breeding seasons; Impairment of long-term reproductive success as a result of subtle, endocrine system impacts; and Reduction in the number of plants that serve as hosts for invertebrates, play a role in successful breeding, or which serve as food sources during parts of the season (8). There also is relatively little data on an ecosystem-scale and multi-generation impacts of pesticide use, yet there is a growing concern in the public about such effects and the resultant limited ability of public agencies to regulate and investigate these potentially deleterious effects of pesticides. 2. Most current use pesticides place stress on biological integrity, habitat/ecosystem health, and proper ecosystem function.
Key impacts selected (critical ecological effects)	1. Copper accumulations in waters and sediments of lakes and ponds with histories of repetitive copper-containing aquatic herbicide treatments; Effects of sub-acute lethal dosages of diquat on early life stages of fish and other marine organisms; Effects of temephos on survival, growth and development of early life stages of fish, amphibians, and other marine organisms; Effects of methoprene on survival, growth and development of early life stages of fish, amphibians, and other marine organisms; Surfactants in formulations containing glyphosate may place fish and invertebrates at risk, particularly at higher water temperatures. The USEPA concluded that many endangered species of plants, as well as the Houston toad, might be at risk from glyphosate use. Surveys on the locations treated and quantities of temephos and methoprene applied to the waters of the State and studies to define the potential of these pesticides for biological impact in New Jersey; Evaluation of nutrient run-off from residential and agricultural fertilizers and from sanitation systems leading to the introduction of greater quantities of aquatic herbicides into fresh-water bodies; Comparative surveys of aquatic organisms in NJ water bodies receiving repetitive non-selective herbicide treatments can provide a measure of their ecological impact. Monitor and evaluate the continued use of toxicity indices (8) as an effective measure of producer discovery and user acceptance of pesticide products with reduced toxicity indices leading to consideration of the possibility such indices may be adapted beneficially to the aquatic situation. Atrazine is moderately toxic to cold water (temperate) fish and slightly toxic to warm water (tropical) fish. Effects on fresh water invertebrates vary from highly to slightly toxic, depending on the type of species. Based on dietary consideration, atrazine is non-toxic to birds ($LC50 > 5000$). There is presently no available data for aquatic plants. However, there are indications that long-term exposure at a higher MCL than 3μg/L could result in adverse effect.
Exposure Assessment	

Exposure routes pathways considered	1.Repetitive and extensive applications of copper-containing aquatic herbicides to the same water bodies (21) may be leading to accumulations of copper that exceed established criteria that would protect most species of freshwater aquatic life from the toxicological effects of accumulated copper in water and sediments. Eisler (5) has proposed these criteria to be 12 µg Cu/l in soft water, 43 µg Cu/l in hard water and 480 mg/kg DW in sediment. The Rome Field Station of the New York State Division of Fish, Wildlife and Marine Resources has conducted studies on the effects of long-term (10 years or more) applications of copper sulfate on copper residues and lake ecosystems to indicate whether copper is indeed a problem and whether current regulations and permitting requirements are adequate to protect lake ecosystems (16). Diquat at levels only slightly below predicted concentrations when used at dosages given by the product label instructions have been reported to cause respiratory distress in yellow perch (2) and cause mortality of fresh water fish during early life stages in New York State(11) may require the prohibition of shallow water and early season applications of this pesticide to alleviate this possible biological risk. Methoprene has been implicated as one of several possible causal agents (4, 9, 15, 23) in the abnormal development, slowed growth rates, and mortality of amphibian tadpoles (1, 3, 4, 9, 14, 17, 18, 19), perhaps acting through retinoid X receptors (7). According to USGS (http://www.npwrc.usgs.gov/narcam/reports/reports.htm), malformed amphibians have been reported in Camden, Middlesex, Morris, Passaic, and Sussex Counties noting that permitted water bodies in Morris, Passaic and Sussex Counties receive a significant portion of the aquatic herbicides applied in New Jersey (Table 3) and unknown quantities of methoprene. Temephos reportedly is toxic to non-target species and inhibits cholinesterase (10, 12, 13, 18, 19, and 20) and is used in New Jersey water bodies in unknown quantities; and has the potential to accumulate in aquatic organisms with bluegill sunfish reportedly having accumulated 2300 times the concentration of this insecticide present in the water. Nitrogen and phosphorus at levels that enhance weed growth can enter lakes in run-off waters resulting in the increased use of aquatic herbicides; Continued use of non-selective herbicides in the aquatic environment can alter the populations and interdependencies of aquatic organisms either by removing vegetation that served as a food source and curtailed soil erosion or by causing herbicide-resistant vegetation forms to develop and perhaps dominate the aquatic habitat leading to silt accumulation; Pesticide toxicity indices may over time serve as a convenient measure of the success of efforts to lead the pesticide industry to develop and use pesticides with reduced toxicity to non-target species; Aquatic herbicides may be applied in some instances in New Jersey at dosages greater than instructed by product labels (Table 3) and greater than required to control the target pest but at dosages too low to produce observable acute lethal responses from the aquatic fauna and a citizen complaint of a misapplication. 2. Pesticide spray can drift and impact non-target organisms. Pesticide run-off can contaminate surface water and groundwater aquifers impacting all organisms that use the water. Registered label uses can provide lethal doses if organisms enter the treated area during critical periods. Organisms, streams and rivers accumulate atrazine and other pesticide residues, which can be transferred to humans when they are eaten as food. Similarly, eating the meat of animals that drink from these surface waters can also transfer these residues to humans.
Population(s)/ecosystem(s) exposed statewide	1. Pesticides are applied to aquatic environments throughout the State to control aquatic weeds, mosquitoes and blackflies and can be applied several times each season to the same areas of water, particularly in shallow waters systems where weeds will grow most densely.

	2. Atlantic, Burlington, Cumberland, Gloucester and Salem counties typically record the heaviest agricultural pesticide use in the state (New Jersey Agricultural Pesticide Survey, 1997). Populations and ecosystems in these counties can expect oxamyl exposure because oxamyl is primarily used as an agricultural pesticide. Populations exposed would include birds and mammals due to their foraging habits. Ecosystems exposed may include surface water due to surface water run-off, soil erosion and ground water leaching. The versatility of diazinon lends to a wide variety of registered uses, including agricultural crops and residential turf and indoor and outdoor pests. Far-reaching impacts can be attributed to such widespread and varied uses. Populations impacted by diazinon may include wildlife, such as beneficial insects, fish and birds, as well as domestic animals. Ecosystems exposed may include surface water due to surface water run-off, soil erosion and ground water leaching. There is potential exposure to non-target organisms in any counties where resmethrin, and similar synthetic pyrethroids are chosen as the method of control for adult mosquitoes.
Quantification of exposure levels statewide	1. Permitted herbicide treatments to the waters of the State are reported annually to the Bureau of Pesticide Operations. Statewide, in 1999, an estimated 600 lbs. of 2, 4-D; 5,620 lbs. of elemental copper; 120,110 lbs. $CuSO_4$; 5,570 lbs. Diquat; 1,950 lbs. Fluridone; and 3,801 lbs. glyphosate were applied to a cumulative 31,473 acres of water surface (21 and Table 3). Much of the pesticide and treated acreage was in Bergen, Monmouth, Morris, Passaic, and Sussex Counties as contrasted to fewer than 25 treated acres in Cape May County. Most mosquito larvicide applications are applied by County agencies currently not required/requested to report their pesticide application activities and quantities to the Bureau of Pesticide Operations. The 2000 New Jersey Mosquito Control Pesticide Use Survey data will be available in Spring 2001. A better assessment can be made at that time regarding the impact of West Nile Virus on application rates. 2. The principal use of oxamyl is on field crops. Therefore, areas of the state with heavy agriculture should be expected to have higher exposures. According to the USEPA (1999), about 800,000 pounds of oxamyl are applied annually in the United States. The New Jersey Agriculture (1997) and Lawn Care (1998) Pesticide Use Surveys indicate that approximately 11,000 pounds of diazinon are applied throughout the state in one year. According to the USEPA (2000), pyrethroids are typically applied at rates of between 0.003 and 0.007 pounds of active ingredient per acres, which is equivalent to 2 to 3.5 fluid ounces of the mixed formulation per acre. The 2000 New Jersey Mosquito Control Pesticide Use Survey data will be available in Spring 2001; a better assessment of exposure levels can be made at that time.
Specific population(s) at increased risk	1. Aquatic species diversity may be shown to be at greater significant risk from continued applications of aquatic herbicides and larvicides in current usage as replicated scientific evidence continues to accumulate. 2. Birds and mammals are at increased risk because oxamyl is typically applied to foliage or other wildlife food items. Diazinon has proven time and again to be lethal to birds. Laboratory toxicity data indicates that fish, aquatic invertebrates and bees are at the greatest risk from non-target exposure.
Quantification of exposure levels to population(s) at increased risk	1. In 1999, an average 4.47 lbs. aquatic herbicide were applied statewide to each surface acre of the waters authorized for treatment by State-issued aquatic permits (Table 3). This ranged from a high of 18 lbs. 2,4-D applied per acre on 33.5 acres to a low of 0.04 lbs. elemental copper (from solid formulation) applied per acre on 180 acres. The statewide data also show that when liquid formulations were used, greater quantities of the active ingredients – elemental copper, endothall, and fluridone - were applied per acre and to a greater number of acres than when solid formulations were used (Table 3). 2. It would be impossible to quantify statewide wildlife exposure to oxamyl.

	It would be impossible to estimate how many birds and other organisms are exposed to diazinon statewide. However, New Jersey Pesticide Use Surveys indicate that 11,000 pounds of diazinon are applied throughout the state in one year. It would not be possible to estimate the numbers of fish, aquatic invertebrates and bees exposed to resmethrin statewide.
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	1. Baseline and persistence levels of residues of currently-used aquatic herbicides and larvicides in samples of water and sediment taken from treated bodies of the State's waters have not been determined and few water and sediment samples have been analyzed in pesticide misuse investigation cases. 2. There appears to be discrepancies between the field/incident data and the acute toxicity recorded in the laboratory (indicating lack of wildlife mortality). However, the USEPA (1999) has concluded "oxamyl may pose high acute and reproductive hazards to avian, mammalian, and amphibian organisms from applications of only 1 pound of active ingredient per acre. These hazards may result even from short-term exposures from only single applications." In 1986, eighty-five American wigeon were killed following a diazinon application at Sudden Valley, Washington Golf Course (Kendall et al., 1987). According to investigators, diazinon was applied at an attempted rate of 2 lbs. a.i./A on nine fairways. The turf residues after application were reported from 183-363 ppm. After irrigation on the day of application, the residues were reported from 100-333 ppm. Samples to measure the application rate indicated the actual application rate ranged from 0.94-5.15 lb. a.i./A. The wigeon died after a reported feeding period of only 30-40 minutes during the late afternoon on the day of the application. In spite of the uneven application rate, all of the residue samples collected on the application day were above the level of diazinon (47 ppm) reported to kill 100% of young mallards in the lab. Diazinon levels in the GI tract and depressed ChE levels in the brain confirmed diazinon as the cause of death. Samples of water from selected public-water-supply drainage basins of New Jersey have been collected and analyzed by the U.S. Geological Survey to determine the content of atrazine and other pesticides in surface waters. Similarly, as part of its evaluation and monitoring program, the Pesticide Evaluation and Monitoring Section of the NJDEP Pesticide Control Program regularly collects water samples from wells throughout the state and analyzes them to determine their pesticide content. Residue detections routinely occur in samples, ranging from a 5% to a 75% rate.
Risk Characterization	

Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	1. The aquatic environment is a dynamic system in which interactions and interdependencies between and among abiotic and biotic elements impact one another. Pesticides by definition are selected to impact directly targeted biological organism(s) judged by the water body's managers and users to be undesirable. The target organism(s) response to the pesticide can indirectly affect other non-target element(s) that depend on or otherwise respond to the affected organism(s). The pesticide selected may also directly and unintentionally impact non-target organism(s) whose response would cause a chain of undesirable effects on other organisms. Pesticides are but one tool used in the management of the water resources contained in the ponds and lakes of New Jersey to achieve agreed upon objectives. In subtle and in less subtle ways pesticides can have unintended and far-reaching effects on the water, on the biota living in the water and sediments, and on the physical basin containing the water. Identifying and evaluating the severity and degree of irreversibility these effects have on the dynamics of the entire system would be a critical tool in the management of essential and vital water resources.	3

	2. There appears to be discrepancies between the field/incident data and the acute toxicity recorded in the laboratory (indicating lack of wildlife mortality). However, the USEPA (1999) has concluded "oxamyl may pose high acute and reproductive hazards to avian, mammalian, and amphibian organisms from applications of only 1 pound of active ingredient per acre. These hazards may result even from short-term exposures from only single applications." Mortality is the primary documented effect on wildlife from organophosphate (OP) and carbamate pesticides (Grue et al., 1983), such as diazinon and oxamyl respectively. According to an article by Linda Glaser of the National Biological Service (1993), "OP and carbamate pesticide toxicity is not specific to a target 'pest' and lethal effects are seen in nontarget organisms; birds appear to be the most sensitive class of animals affected by these pesticides". The article also indicates that wildlife mortality resulting from OP and carbamate poisoning has been documented for more than 20 years and has been on the rise since 1980 (Glaser, 1993). The USEPA (1999) has cited diazinon as the cause of approximately 300 incidents of wildlife mortality. While intentional bird poisonings involving Diazinon are not uncommon; bird kills are often associated with registered uses of diazinon.	

	The high mortality rate of wildlife associated with diazinon represents more than isolated incidents of bird deaths. It clearly indicates that this insecticide, and others similar organophosphates, have the ability to devastate the environment through registered, "legal" uses. Diazinon is intended to control insect pests, and yet there is repeated evidence that it kills living things far beyond the scale of its intended use. Mortality is the primary documented effect on wildlife from organophosphate (OP) and carbamate pesticides (Grue et al., 1983), such as diazinon and oxamyl respectively. According to an article by Linda Glaser of the National Biological Service (1993), "OP and carbamate pesticide toxicity is not specific to a target 'pest' and lethal effects are seen in nontarget organisms; birds appear to be the most sensitive class of animals affected by these pesticides." The article also indicates that wildlife mortality resulting from OP and carbamate poisoning has been documented for more that 20 years and has been on the rise since 1980 (Glaser, 1993). If wildlife mortality resulting from pesticide poisoning continues, biological integrity, biodiversity, and ecosystem health and function may experience further declines. Current regulations related to this problem might not prove adequate to protect wildlife from the lethal effects of OP and carbamate poisoning. Widespread spraying in reaction to the West Nile Virus provides ample opportunity for non-target exposure to resmethrin and other synthetic pyrethroids. Non-target exposure poses the greatest threat to fish and aquatic invertebrates and beneficial insects such as bees. The EXTOXNET Pesticide Information Profiles rates resmethrin as very highly toxic to fish and highly toxic to bees.	

	According to the EPA, resmethrin is typically applied as an ultra low volume (ULV) spray. ULV sprayers produce a very fine mist that stays afloat and kills adult mosquitoes on contact. This type of ULV application has great potential for drift into non-target areas. As organophosphates and carbamates become less heavily used, the use of synthetic pyrethroids is going to increase dramatically. In particular, relying on one type of insecticide for mosquito control could lead to the development of mosquitoes resistant to that particular insecticide. If the mosquitoes were to become resistant to synthetic pyrethroids, even more deadly pesticides would have to be introduced into the environment to combat the mosquitoes. Not only would this have an adverse effect on mosquito control in general, but any vector-borne illness the mosquitoes are carrying would be out of control. Atrazine is toxic to fish and is a possible human carcinogen. Nevertheless, its concentration in surface waters seldom exceeds the MCL level of 3μg/L, except during spring and early summer when applications are made in agricultural areas. Also, because its concentration in wells and public water supply drainage basins is very low (<1μg/L), there is no apparent effect. pesticide poisoning continues, biological integrity, biodiversity, and ecosystem health and function may experience further declines. Current regulations related to this problem might not prove adequate to protect wildlife from the lethal effects of OP and carbamate poisoning.	

	Widespread spraying in reaction to the West Nile Virus provides ample opportunity for non-target exposure to resmethrin and other synthetic pyrethroids. Non-target exposure poses the greatest threat to fish and aquatic invertebrates and beneficial insects such as bees. The EXTOXNET Pesticide Information Profiles rates resmethrin as very highly toxic to fish and highly toxic to bees. According to the EPA, resmethrin is typically applied as an ultra low volume (ULV) spray. ULV sprayers produce a very fine mist that stays afloat and kills adult mosquitoes on contact. This type of ULV application has great potential for drift into non-target areas. As organophosphates and carbamates become less heavily used, the use of synthetic pyrethroids is going to increase dramatically. In particular, relying on one type of insecticide for mosquito control could lead to the development of mosquitoes resistant to that particular insecticide. If the mosquitoes were to become resistant to synthetic pyrethroids, even more deadly pesticides would have to be introduced into the environment to combat the mosquitoes. Not only would this have an adverse effect on mosquito control in general, but any vector-borne illness the mosquitoes are carrying would be out of control. Atrazine is toxic to fish and is a possible human carcinogen. Nevertheless, its concentration in surface waters seldom exceeds the MCL level of 3μg/L, except during spring and early summer when applications are made in agricultural areas. Also, because its concentration in wells and public water supply drainage basins is very low (<1μg/L), there is no apparent effect.	

Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	1. The use of pesticides in the aquatic environment is determined ultimately by those who depend upon and use the water for their end purposes through those responsible for day-to-day management and control of the water bodies in question. Therefore, the selection and frequency of use of pesticides and, ultimately the frequency and intensity of the effect of the pesticides on the aquatic environment, is determined by those who depend upon and use the water and expect it to be of high quality and safe to use upon demand. The demand can be expected to increase as the population of fresh water body users expands the development of the states water bodies. Generally, those who manage the water body and the end users of the water body and its products desire to use pesticides that target specific pests producing minimal secondary effects with minimal applications and residues without sacrificing the end objective – eliminating or greatly reducing the presence of the target pest. 2. Although reports of wildlife mortality incidents were unavailable, laboratory studies indicate that oxamyl is acutely toxic to birds and mammals. Oxamyl is typically applied directly to crop plants or the surface soil. This manner of application greatly increases the risk of exposure to birds and mammals. It has been suggested that this exposure risk could be reduced if oxamyl was incorporated directly into the soil.	3

	This would not only reduce the opportunity for exposure to a foraging bird or mammal, but would also reduce the oxamyl available for run-off at the surface. The USEPA (1999) has attributed 300 occurrences of wildlife mortality (primarily birds) to diazinon, with the largest number of incidents occurring on turf sites, including residential lawns. These incidents range in size from a single bird to hundreds of birds. According to the USEPA (1999), there has been a trend of steadily increasing numbers of incidents over the past few years. In the past five years, more incidents of wildlife mortality have been reported for diazinon than for any other pesticide. Potential for non-target exposure exists as long as the West Nile Virus is present in the northeastern United States. Blanket applications to high-risk areas are common. Large-scale applications hold the greatest potential for non-target exposure to organisms such as fish and bees. If the West Nile Virus is discovered in Spring 2001, there is potential for frequent spraying far beyond the original detection areas in New York and New Jersey. The be exceeded when applications to agricultural land are lost as runoff to surface waters.	

Size of population(s) and/or extent of the State affected (magnitude) 5- >50% of the State impacted 4- 25-50% of the State impacted 3- 10-25% of the State impacted 2- 5-10% of the State impacted <5% of the State impacted (NOTE: we are assessing the magnitude of impacts, i.e., if impacts occur to 5-10% of the entire state = "2"; a "5" implies that more than ½ of all ecosystems in the state have measurable impacts.)	West Nile Virus is discovered in Spring 2001, there is potential for frequent spraying far beyond the original detection area in New York and New Jersey. The results of the 2000 New Jersey Mosquito Control Pesticide Use Survey data will provide a better assessment of exposure levels. During most of the year, atrazine concentration in surface waters is less than the maximum contaminant level of 3μg/L recommended by EPA. However, in spring and early summer this level may be exceeded when applications to agricultural land are lost as runoff to surface waters. 1. The entire state population as owners of the State's waters is affected by changes in the aquatic habitat by virtue of their expectations and interests in a healthy and viable aquatic habitat, safe and healthy potable water, and recreational water quality. 2. Oxamyl is primarily an agricultural pesticide. Approximately 20% of the land in New Jersey is occupied by some type of agriculture, which increases wildlife exposure to agricultural pesticides, such as oxamyl. Due to the variety of registered uses of diazinon, this insecticide and other organophosphates with similar functions, are widely used throughout all of New Jersey.	2-3
	Diazinon is applied to the agricultural crops in the southern and northwestern counties, but is also heavily used for lawn care and indoor/outdoor pest control in urban and suburban areas. The New Jersey	

	Agricultural (1997) and Lawn Care (1998) Pesticide Use Surveys indicate that approximately 11,000 pounds of Diazinon are applied throughout the state in one year. Because of the human health issues associated with the West Nile Virus, blanket applications of synthetic pyrethroids have occurred in counties with West Nile detections and as preventative measures elsewhere. Each application will typically deliver 2 to 3.5 fluid ounces of mixed formulation per acre. It would be difficult to accurately estimate the size of the ecological population affected.	
	Total	18-27
Assessment of uncertainties in this assessment (H,M,L) and brief description	1. (H) The complexities of the dynamic aquatic ecosystem and the diversity of interests in the State population do not provide for facile determination of a definition for the "ideal" system and the purpose of the system to which all would agree. Some segments of the population desire a "natural" water body; others desire a water body in which it is convenient to swim and boat and/or yields fish; and still others desire a water body that yields potable water. Different segments of the state population have differed strongly in their definitions of what is desirable and undesirable. 2. (M) It appears that the major route of exposure for birds and mammals is foraging in recently treated areas and ingestion of soil contaminated with oxamyl. However, the USEPA (1999) has identified a lack of toxicity data for species that would typically come in contact with soil as part of their diet. Comprehensive diet studies of birds and mammals would provide better insight into the methods of application that would reduce exposure to oxamyl and other carbamates. (H) According to the USEPA (1999), the major uncertainty in assessing diazinon is the lack of data covering each of the registered uses. For instance, very little information is available regarding the non-agricultural uses of diazinon, which constitute nearly 70% of the active ingredient applied in one year. (H) No field/incident data was readily available to support the acute toxicity findings recorded in the laboratory for resmethrin.	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	1. (H) Further understanding of the effects of pesticides on the dynamics of New Jersey aquatic ecosystems would lead to the safer use of existing pesticides and to the intentional development and use of new pesticides having a less deleterious impact on non-target organisms, particularly at sub-acute or chronic dosages, and on early life stages of responsive non-target species. Quantities of mosquito larvicides applied by various agencies throughout the state are not reported to a central office for evaluation. Quantities of aquatic herbicides applied throughout the state are reported to a central office but dosages applied are not evaluated for compliance with label instructions and permit requirements. 2. (M) Two degradation products have been detected in association with oxamyl: oxime and dimethyloxamic acid	

	(DMOA). Data suggests that these compounds may be more mobile and persistent in the environment than the parent oxamyl. However, the data regarding these degradation products is fair to limited to accurately assess the toxicity and exposure risks for oxime and DMOA. Among the data gaps surrounding diazinon and other similar organophosphates are the following: 1) lack of information regarding specific registered uses and 2) lack of information regarding degradation products. In the case of diazinon, 70% of active ingredient is applied in non-agricultural settings, such as residential turf. Since most of the bird kills are associated with turf applications, further research into this registered use could dramatically reduce the number of bird kills. Furthermore, the effects of diazinon's degradation products, diazoxon and oxypyrimidine, are unknown. However, data related to human health effects indicate that diazoxon may be even more toxic than the parent diazinon. Again, further research into the degradation products would reduce potential adverse effects on all of New Jersey's wildlife, not just birds. (H) The toxicity of resmethrin and other synthetic pyrethroids has been assessed in the laboratory. The available information indicates that synthetic pyrethroids can have severe impacts on the environment and wildlife. The lack of data on non-target impacts, specifically impacts on the environment and wildlife, is a critical gap in knowledge. There is also very little information available about the degradation products of the synthetic pyrethroids. Like other insecticides, the degradation product can prove even more toxic than the parent compound.
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, !, =, ≡; where + is improvement), and brief description.	1. (+) Definition and documentation of the impacts caused by pesticides would be a guiding force for future actions to control the extent of undesirable effects. Discovering the significance of the sensitivities of non-target species in early life stages to lethal and chronic dosages of pesticides conceivably could lead to a more complete and precise regulation and monitoring of pesticide usage and to the use of pesticides with lower ecological toxicity indices. 2. (++) If soil injection methods were the sole method of oxamyl application to field crops, the risk to foraging mammals and birds would be significantly reduced. Soil incorporation would reduce overall exposure and access to the compound. The high mortality rate of wildlife associated with diazinon represents more than isolated incidents of bird deaths. It clearly indicates that this insecticide, and other organophosphates, has the ability to devastate the environment through registered, "legal" uses. Wildlife exposure to diazinon, and similar organophosphates, could be greatly reduced through reevaluation of these key factors. If further research could determine the mechanisms by which non-target organisms are impacted by synthetic pyrethroids, steps could be taken to reduce non-target exposure. The key is to effectively eliminate **ONLY** the target pest with a broad-spectrum insecticide. The potential for future change in the underlying risk from atrazine is dependent on changes in the regulation controlling the use of this pesticide, and changes in the practice of farmers and other users. Regulatory changes may involve further revision of labels. On the other hand, farmers can reduce runoff losses by adopting best management practices that include IPM, setting buffer strips to trap runoff, conservation tillage to reduce soil erosion, reducing application rate, timing of applications so as not to be followed immediately by rain, subsurface drainage, contour planting, crop rotation, and stripcropping.
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	L: Potential for short-term drastic widespread impacts are low. On a longer time scale the potentials for impacts are estimated as : 1. (M) Loss of environmental diversity, however "slight", may not be reversible and ultimately may become magnified by a larger and yet undefined cumulative impact on the total environment. (M) Chronic reproductive effects for birds and mammals have also been associated with one exposure to a carbamate

	compound (Jewell et al., 1998). Reduced egg production and egg fertility in birds and decreased body weight during lactation in mammals has been observed (USEPA, 1999). Oxamyl is typically applied on a variety of crops during critical periods of bird and mammal reproduction. This increases the risk of acute and chronic reproductive effects through ingestion and dermal absorption. Population diversity could be devastated if the majority of birds in a large roost all suffer reproductive failures. Unless the registered uses and application rates posing the highest risk are reevaluated, certain bird populations could eventually reach dangerously low numbers. It has been demonstrated that synthetic pyrethroids have a devastating effect on aquatic invertebrates and fish (Mueller-Beilschmidt, 1990.) Although the synthetic pyrethroid themselves have not been cited as toxic to birds, birds can be indirectly affected if their food supply is altered or eliminated. Waterfowl that feed on aquatic invertebrates are especially vulnerable. If the non-target impacts of synthetic pyrethroids are not explored further, the results could be catastrophic for our ecosystems. Although some pesticides in surface waters are rarely detected, there are others that may exceed the maximum contaminant level (MCL) during the spring and early summer when applications are made to agricultural land. However, their annual average concentrations seldom exceed the regulatory standard established by EPA. Therefore, the potential for any catastrophic adverse effect on humans, fish and other aquatic life is low.
Link to other Work Groups (e.g., socioeconomic impacts)	1. Stressors other than pesticides can produce their own unique environmental impacts as well as exacerbate pesticide effects. Separation of these effects from one another together with identifying possible additional effects of aquatic herbicides and larvicides on non-aquatic systems require the cooperative efforts of other work groups. 2. Human Health through ingestion of contaminated water and/or food. Because atrazine is toxic to fish, it could be detrimental to the freshwater fish industry. Therefore, enforcement of appropriate regulations by federal and state regulators is necessary to control its concentration in the streams, rivers, and lakes of the state.
Extent to which threat is currently regulated or otherwise managed	All pesticides are regulated by federal or state laws and regulations. The NJDEP Pesticide Control Program (PCP) currently licenses all pesticide applicators and operators throughout the state. In order to promote the responsible use of pesticides, applicators and operators are required to attend state-approved certification sessions. The PCP Enforcement Staff also promotes the responsible use of pesticides through citing individuals who do not follow the pesticide label's instructions (i.e. "the label is the law".) Outreach programs also help to educate the public on the safe and responsible use of pesticides. The PCP also conducts monitoring projects to determine the ecological impacts of pesticides specific to New Jersey. These projects monitor the soil and ground and surface water throughout the state. 1. Regulation, permit requirements, enforcement, and management of threats to the environment have historically been more responsive to the discovery of adverse impacts than anticipation of possible adverse impacts. As adverse impacts became known, new batteries of biological tests were devised to test pesticide active ingredients for their suitability for introduction into surface waters; and new regulations and permit requirements were enacted to control and ensure safe pesticide usage. 2. The USEPA has classified most products containing oxamyl as Restricted Use Pesticides, which may only be purchased and used by certified applicators. Diazinon is no longer registered for use on golf courses and sod farms. Resmethrin is a Restricted Use Pesticide, which is only available for use by certified pesticide applicators due to its toxicity to fish. Other synthetic pyrethroids also carry restricted use status due to their potential for devastating effects to wildlife and the environment. There are certain safe guards both at the Federal and State levels, which have been put in place to protect human

	health and aquatic life from the adverse effects of pesticides in surface and ground water. Under provisions of the safe drinking water act, the USEPA has established an enforceable maximum contaminant level (MCL) of 3 μg/L in drinking water for atrazine. The MCL is a health-based standard obtained from chronic toxicity studies with animals. There is also the maximum contaminant level goal (MCLG) for pesticides with known MCL. The MCLG is a non-enforceable concentration that allows for an adequate margin of safety. The MCLG is set at zero for a known or probable human carcinogen, such as alachlor. But for atrazine, a possible human carcinogen, the MCLG is 3 μg/L. Also, for pesticides with no established MCLs, the USEPA has issued drinking water health advisory (HA) levels for adults and children for various exposure periods. There is also the Suggested No-Adverse-Response Level (SNARL). Both HA and SNARL values represent estimates of the maximum level of a contaminant at which no adverse effects would be expected. Other safety measures that have been taken include, amending product label to classify atrazine as a restricted use pesticide so that only certified applicators can use it; setting back the distance from wells to prevent application in immediate well surroundings; and eliminating its use for noncrop and total vegetation control.
Barriers to restoration	1. Increased knowledge and understanding of the effects of pesticides on target and non-target aquatic species invariably lead to additional USEPA testing requirements for the pesticide active ingredient before it may be registered or re-registered. Such tests usually require substantial additional investment of time and resources by the pesticide producer and may lead to the decision by the producer not to bring the product to the marketplace or to remove the product from the marketplace without testing. Scientific documentation of adverse impacts on the aquatic environment and their remedies usually by publicly supported research and pilot projects which are costly and time-consuming. The public expects public health and the quality and quantity of potable and recreational waters to be maintained and/or improved. Restoration of an aquatic ecosystem may not be accomplished by the mere withholding of the further applications of the offending pesticide. For example, the determination to physically remove a pesticide with a long residual life or tightly bound to the sediment, or the decision to reintroduce and establish a depleted aquatic species may produce unique sets of environmental problems. 2. The effectiveness and cost of soil incorporation of oxamyl versus current methods may hinder wildlife exposure reduction. If soil incorporation proves to cost more and be less effective, the agricultural community may not embrace the change. It is nearly impossible to keep wildlife, especially birds, from entering an area that has been treated with an insecticide. Even if entry on the application day could be restricted, a die off was reported 3 months after an application of diazinon (Zinkl et al., 1978). Although data gaps exist regarding the toxicity of resmethrin and other synthetic pyrethroids, it has been determined that the beneficial effect in controlling the West Nile Virus outweighs the risk to the environment and wildlife. Human health versus healthy ecosystems? This question is an overwhelming barrier.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	L L Although there is no available data, atrazine like any other pesticide can accidentally be released into storm drains

	and then into surface waters.
Small business industry	H Are contracted to apply aquatic herbicides and usually responsible for selection of pesticide. L Accidental spills at mixing sites, direct disposal by landscapers and farm workers, and runoff from application sites. (L)
Transportation	L L Spills on roadways from transportation trucks. (L)
Residential	H A principle beneficiary of and contracting party for aquatic weed control and beneficiary of larviciding treatments as well as requiring safe and high quality potable water to apply aquatic herbicides and usually responsible for selection of pesticide. H The USEPA (1999) lists the largest, non-agricultural use of diazinon and similar pesticides as the control of homeowner outdoor insect control for turf and garden.
Agriculture	L H - The USEPA (1999) indicates that oxamyl is used on 30 different fruit, vegetable and field crops, including apples and tomatoes. Diazinon is used on a wide variety of agricultural crops grown in New Jersey, such as peaches, apples and blueberries. Synthetic pyrethroids are applied as broad-spectrum insecticides to many agricultural crops grown in New Jersey, such as apples, peaches and blueberries. Because atrazine is the most heavily used herbicide on cropland, agriculture is a major cause of atrazine pollution of surface and ground water. For example, 58,790 lbs. of atrazine were used for agriculture in New Jersey and Long Island during 1994.
Recreation	H A principle beneficiary of and possible contracting party for aquatic weed control and beneficiary of larviciding treatments. L Runoff from wooded areas around parks.
Resource extraction	L L
Government	H County and state agencies are responsible for controlling mosquito vectors and black flies in the waters of the State. H Synthetic pyrethroids make up a large portion of most Mosquito Control Programs throughout the state.
Natural sources/processes	L L
Orphan contaminated sites	L M This would depend on if such sites are used as dumping ground for pesticide containers and/or industrial wastes of pesticide manufacturing establishments.
Diffuse Sources	
Sediment sinks	M Possible accumulation of various copper species with long half-lives and of other organic pesticides strongly adsorbed to organic fraction of water body sediments. L Atrazine does not only get dissolved in run-off water but it also gets attached to sediments transported in run-off.
Soil sinks	L L Certain pesticides, like atrazine, are mobile in soil and hence they can leach into ground water and subsequently

	move into surface water by base flow.
Non-local air sources incl. deposition	L L Pesticide sprays and volatile products from treated surfaces can be transported in non-local air masses and be deposited in lakes, ponds, streams, and rivers.
Biota sinks	L Decay of biological organisms releases pesticide and metabolites into water for reabsorption and possible dissipation; pesticides may also accumulate in the food chain. L Bioaccumulated pesticide residue in fish and other aquatic organisms can be re-released into surface waters upon their death.

Summary Statement:

1. Aquatic herbicides and mosquito larvicides are applied in New Jersey primarily to inland waters and to wetland areas to control weeds, mosquitoes and blackflies, and other nuisance insects. Wetland areas are frequently located in wooded areas. As residential development expands throughout the state, the demand for high quality and aesthetically pleasing water bodies, for recreational areas, and for reliable sources of potable water increases. Compared with other commonly used pesticides, the short-term acute toxicity hazards of aquatic herbicides and larvicides to non-target aquatic organisms are relatively low. However, evidence is beginning to emerge to indicate that exposure of non-target aquatic organisms in early stages of development to aquatic herbicides and larvicides at levels below those causing acute toxicity responses may also adversely impact desirable species of the aquatic habitat. Additionally, the absence of facile observations of symptoms of acute toxicity to aquatic fauna may lead to the unreported application of pesticides at dosages in excess of those instructed by the product label.

Once applied to the water of a lake or pond, a pesticide, depending on its physical organic and inorganic chemical characteristics may, in varying degrees, remain in the water to flow downstream or to percolate into the ground water; partition into the aquatic biota, suspended particles and/or the underlying sediment. Some may also enter the atmosphere through evaporation from spray droplet and water body surfaces. Ameliorating the threat of unaltered pesticide molecules to the environment are biological and non-biological degradation of the pesticide molecule or binding of the molecule to various fractions of the sediment and suspended particles so tightly as to be unavailable to the aquatic habitat. For example, of the herbicides and larvicides currently applied to fresh water ponds and lakes in New Jersey, the mosquito larvicide, temephos, has been reported to have the potential to accumulate in aquatic organisms such as the common bluegill sunfish which is reported to accumulate this larvicide at 2300 times the concentration present in the water. Nearly 75% of the accumulated temephos was eliminated from the fish after removal from exposure. Temephos also has a low persistence in water and sediment.

Even though aquatic herbicides and mosquito larvicides currently applied to the fresh waters of the State are perceived as having a relatively low persistence in water and sediment and low acute toxicities to non-target organisms, attention and concern is being turned to the effects of sub-acute or chronic dosages of these pesticides to non-target organisms. The effects of sub-acute lethal levels of aquatic pesticides on early growth stages of non-target fish and amphibians and insects, and of herbicide-induced changes in plant populations may be magnified in the survival rates and population shifts of dependent aquatic species. Little is known of the potential effects on aquatic ecosystems of currently used pesticides at sub-acute and plant population-altering dosages necessitating the development of further information of these effects.

2. Oxamyl is a carbamate insecticide used on field crops, vegetables, fruits and ornamental plants to control a broad spectrum of insects, mites, ticks and roundworms. Pesticide spray can drift and into non-target areas and run-off into surface and ground water. Registered label uses can also provide lethal doses to non-target organisms. Birds and mammals are at increased risk because oxamyl is typically applied to foliage or other wildlife food items. Oxamyl is typically applied on a variety of crops during critical periods of bird and mammal reproduction. This increases the risk of acute and chronic reproductive effects through ingestion and dermal absorption. Population diversity could be devastated if the majority of birds in a large roost all suffer reproductive failures.

Issue: Pesticides-Present Use
Author: Rush/Meyer
Version: 03/01;04/05/01
Diazinon is a broad-spectrum, organophosphate insecticide. As an organophosphate, it works as a cholinesterase inhibitor for all exposure pathways and durations. Its versatility lends to a wide variety of registered uses, including agricultural crops and residential turf and indoor and outdoor pests. Pesticide spray can drift into non-target reas and run-off into surface and ground water. Registered label uses can also provide lethal doses to non-target organisms. Due to the heavy use of diazinon on turf, birds that feed on turf are at increased risk. Bird kills and adverse effects on other organism will continue until the use patterns and methods are reevaluated.

Resmethrin is a broad-spectrum insecticide used to control insect pests in agriculture, households, stored products and mosquito control. Resmethrin is one of over 1000 insecticides that belong to a diverse class called the synthetic pyrethroids. Pesticide spray can drift into non-target areas and run-off into surface and ground water. Registered label uses can also provide lethal doses to non-target organisms. Laboratory toxicity tests indicate that fish, aquatic invertebrates and bees are at increased risk from non-target exposure. Although the synthetic pyrethroid themselves have not been cited as toxic to birds, birds can be indirectly affected if their food supply is altered or eliminated. Waterfowl that feed on aquatic invertebrates are especially vulnerable. If the non-target impacts of synthetic pyrethroids are not explored further, the results could be catastrophic for our ecosystems.

Statewide Analysis of Threat Threat = Current Use Pesticides

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	3	3	5	45
Marine Waters	1	1	1	1
Wetlands	3	3	5	45
Forests	2	2	2	8
Grasslands	2	1	1	2
			Total Score	101
			Average Score (Total ÷ 5)	20.2

Risk by Watershed Management Region –Current Use Pesticides

THREAT	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	H	NA	H	M	L
Passaic	H	NA	H	M	L
Raritan	M	NA	M	L	L
Atlantic Coastal	M	NA	M	L	L
Lower Delaware	M	NA	M	L	L

Issue: Pesticides-Present Use
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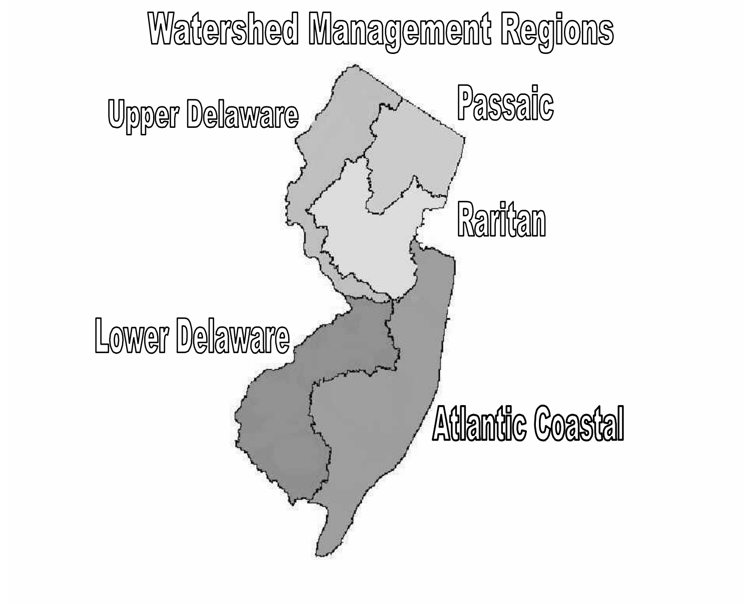
Version: 03/01;04/05/01

Region/Watershed (secondary)	Upper Delaware	Passaic	Raritan	Atlantic Coastal	Lower Delaware
Urban	NA	M	M	NA	NA
Suburban	M	M	M	L	L
Rural	M	M	M	M	M

H=high, M=medium, L=low, NA = not applicable



Oxamyl References:

Beyer, W.N., E.E. Conner and S. Gerould. 1994. Estimates of soil ingestion by wildlife. J Wild. Management 58(2):375-382.

Glaser, Linda C. 1993. Wildlife Mortality Attributed to Organophos-phorus and Carbamate Pesticides. National Biological Service, Department of the Interior.

Grue, C.E. , A.D.M. Hart, and P. Mineau. 1991. Biological consequences of depressed brain cholinesterase activity in wildlife. Pages 151-209 in P. Mineau, ed. Cholinesterase-inhibiting insecticides. Elsevier Science Publishers, Amsterdam, The Netherlands.

Jewell, W.T. , R.A. Hess and M.G. Miller. 1998. Testicular toxicity of Molinate in the rat: metabolic activation via sulfoxidation. Toxicology and Applied Pharmacology 149:159-166.

United States Environmental Protection Agency. 1998. Consumer Factsheet on: Oxamyl (Vydate). Office of Ground Water and Drinking Water, Environmental Protection Agency.

United States Environmental Protection Agency. 1999. RED Chapter for Oxamyl (103801). Division of Environmental Fate and Effects, Environmental Protection Agency.

Diazinon References:

Grue, C.E. , A.D.M. Hart, and P. Mineau. 1991. Biological consequences of depressed brain cholinesterase activity in wildlife. Pages 151-209 in P. Mineau, ed. Cholinesterase-inhibiting insecticides. Elsevier Science Publishers, Amsterdam, The Netherlands.

Kendall, R. J., Brewer, L. W. and Hitchcock, R. R. 1987. Avian Response to and Environmental Chemistry of Turf Applications of Diazinon AG500 in Western Washington. Final Report. Institute of Wildlife Toxicology, Huxley College of Environmental Studies, Western Washington University, Bellingham, WA (unpublished).

United States Environmental Protection Agency. 1999. Memorandum, EFED RED Chapter for Diazinon, PC Code No. 057801, Case #818962. Environmental Fate and Effects Division, Environmental Protection Agency.

United States Environmental Protection Agency. 2000. Diazinon Summary. Office of Pesticide Program, Environmental Protection Agency.

Zinkl, J. G., Rathert, J. and Hudson, R. R. 1978. Diazinon poisoning in wild Canada geese. J. Wildl. Manage. 43 (2): 406-408.

Resmethrin References:

Extension Toxicology Network. June 1996. Pesticide Information Profiles-Resmethrin.

Toxicology and Environmental Fate of Synthetic Pyrethroids. Doria Mueller-Beilschmidt. Journal of Pesticide Reform, Volume 10, Number 3, Fall 1990. Northwest Coalition for Alternatives to Pesticides, Eugene, OR.

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United States Environmental Protection Agency. 2000. For Your Information-Synthetic Pyrethroids for Mosquito Control. Pollution Prevention, Pesticides and Toxic Substances, Environmental Protection Agency.

Atrazine References:

Barbash, J.E. and Resek, E.A., 1996, Pesticides in ground water: distribution, trends, and governing factors. vol. 2. Ann Arbor Press, Inc., Chelsea, Michigan.

EPA office of pesticides and toxic substances – office of water (1991): questions and answers. U.S.G.S. survey report on herbicides in the Mississippi River Basin.

EPA. (1994) Questions & answers: special review of the triazine pesticides – atrazine, cyanazine, and simazine.

Ivahnenko, T. and D. Buxton, 1990, Agricultural pesticides in six drainage basins used for public water supply in New Jersey. U.S.G.S. water-resources investigations report #93-4101.

Larson, S.J., Capel, P.D. , and Majewski, M.S., 1997, Pesticides in surface waters: distribution, trends, and governing factors. vol. 3, Ann Arbor Press, Inc., Chelsea, Michigan.

U.S.D.A. (2000) Conservation buffers to reduce pesticide losses.

U.S.G.S. (1995). Pesticides in the atmosphere. Fact sheet #FS-152-95

U.S.G.S. (1997) Pesticides in surface waters. Fact sheet #FS-039-97

U.S.G.S.(1999) Nitrates, volatile organic compounds, and pesticides in ground water: a summary of selected studies from New Jersey and Long Island, NY. U.S.G.S. water-resources investigations report #99-4027.

U.S.G.S. (1999) Pesticides in streams in New Jersey and Long Island, NY, and relation to land use. Water resources investigative report #98-4261.

Aquatic Herbicide References:

Ankley, G. T., J. E. Tietge, D. L. DeFoe, K. M. Jensen, G. W. Holcombe, E. J. Durhan, S A. Diamond, and P. K. Schoff. 1998. Effects of methoprene and UV light on survival and development of *Rana pipiens*. Abstract. Midwest Declining Amphibians Conference. http://www.mpm.edu/collect/vertzo/herp/DAPTF/Mwabst.html.

Bimber, K. L. 1976. Respiratory stress in yellow perch induced by subtoxic concentrations of diquat. Ohio J. Sci. 76(2):87-90.

Blumberg, B., D. M. Gardiner, D. Hoppe, and R. M. Evans. 1998. Field and laboratory evidence for the role of retinoids in producing frog malformities. Abstract. Midwest Declining Amphibians Conference. March 20-21, 1998. http://www.mpm.edu/collect/vertzo/herp/DAPTF/Mwabst.html.

Bury, C. 1998. Freaky Frogs, Big Mystery. http://www.archive.abcnews.go.com/sections/science/DailyNews/frogs.html. 6 p.

Eisler, R. 1998. Copper hazards to fish, wildlife, and invertebrates: A synoptic Review. Biological Science Report USGS/BRD/BSR—1997-0002. Report No. 33. 98 p.

Gilliom, R. J. 2000. Pesticides in Stream Sediment and Aquatic Biota. USGS Fact Sheet 092-00. http://water.wr.usgs.gov/pnsp/rep/fs09200/.

Harmon, M. A., M. R. Boehm, R. A. Heyman, and D. J. Mangelsdorf. 1995. Activation of mammalian retinoid X receptors by the insect growth regulator methoprene. Proc. National Acad. Sci. U.S.A. 92(13):6157-6160.

Lynch, S. and C. Benbrook. . 1998. WWF/WPVGA collaboration for pesticide risk reduction background and first-results. Integrated Pest Management Measurement Systems Workshop. www.farmlandinfo.org/cae/wp/sp98-1/ipmbenb.htm.

Montague, P. Another pesticide surprise. http://www.npwrc.usgs.gov/narcam/info/news/pesticid.htm. 6 p.

Paul, E. A. and T. J. Sinnott. Information Bulletin. October 30, 2000. Fish and wildlife related impacts of pesticides used for the control of mosquitoes and blackflies. New York State Department of Environmental Conservation Division of Fish, Wildlife, and Marine resources. Bureau of Habitat. 14 p.

Paul, E. A., H. A. Simonin, and J Symula. 1994. The toxicity of diquat, endothall, and fluridone to the early life stages of fish. J. Freshwater Ecology 9(3):229-239.

Pinkney, A. E., P. C. McGowan, D. R. Murphy, T. P. Lowe, D. W. Sparling, and L. C. Ferrington. 2000. Effects of the mosquito larvicides temephos and methoprene on insect populations in experimental ponds. *From* Abstract. Environ. Toxicol. Chem. 19(3):678-684.

Pinkney, A. E., P.C. McGowan, D. R. Murphy, T. P. Lowe, D. W. Sparling, and W. H. Meredith. 1999. (Abate-4E) on fiddler crabs(*Uca pubnax* and *Uca minax*) on a Delaware salt marsh. *From* Abstract. J. Amer. Mosq. Control Assoc. 15:321-329.

Schmidt, C. W. 1997. Amphibian deformities continue to puzzle researchers. Environ. Sci. Technol. 31(7):324A-326A.

Sessions, S. K. and S. B. Ruth. 1990. Explanation for naturally occurring supernumerary limbs in amphibians. J. Experimental Zoology 254:38-47.

Simonin, H. 2000. NY Department of Environmental Conservation. Division of Fish, Wildlife and Marine Resources. Bureau of Habitat – Rome Field Station. http://www.dec.state.ny.us/website/dfwmr/habitat/hoa1b2e.htm. 6 p.

Sparling, D. W. 1998. Field evidence for linking Altosid applications with increased amphibian deformities in southern leopard frogs. Abstract. Midwest Declining Amphibians Conference. March 20-21, 1998. http://www.mpm.edu/collect/vertzo/herp/DAPTF/Mwabst.html.

Sparling, D. W. 1998. Effects of Altosid and Abate-4E on deformities and survival in southern leopard frogs under semi-natural conditions. Proceedings of the 1998 declining amphibians conference. J. IA Acad. Sci. 107(3-4, Special Issue).

Sparling, D. W. and P. T. Lowe. Chemicals used to control mosquitoes on refuges differ in toxicity to tadpoles. http://www.pwrc.nbs.gov/tadnew.htm. 4 p.

Sparling, D. W., T.P. Lowe, and A. E. Pinkney. 1997. Toxicity of Abate to green frog tadpoles. *From* Abstract. Bull. Environ. Contam. Toxicol. 58:475-481.

Still, T. 2000. Personal Communication.

Wendt-Rach, L. 1998. Biodiversity and Herbicides in Freshwater Ecosystems. http://www.ecotox.lu.se/STAFF/LWR/Lwintrou/Lwintrou.html. 30 p.

Issue: Pesticides-Present Use
Author: Rush/Meyer
Version: 03/01;04/05/01

Zaga, A., E. E. Little, C. F. Rabeni, and M. R. Ellersieck. 1998. Photo-enhanced toxicity of a carbamate insecticide on early life stage amphibians. Abstract. Midwest Declining Amphibians Conference. March 20-21, 1998. http://www.mpm.edu/collect/vertzo/herp/DAPTF/Mwabst.html.

Additional Resources:

Pothoven, S. A. 1996. An evaluation of the indirect effects of fluridone on the fish community structure of two Minnesota lakes. M.S. Thesis. Univ. Minnesota, St. Paul. 141 pp.

Winter, J., R. Patino, and E. D'Silva. 1997. TTU studies impact of low levels of herbicides on fish. New Waves 10(3):August, 1997.

Table 1
Scaled and Weighted Toxicities of Selected Pesticides[a]

Pesticide	Scaled Index[b]				Cumulative Weighted Indices[c]		
	Acute Mammalian	Chronic Mammalian	Acute Ecological	gioIPM	Equal (Summed)	Human Health	Ecological Effects
Paraquat'	2.9	19.47	12.9	38.1	73	48	108
$CuS0_4$	1.46	0.29	6.4	23.2	31	11	60
Diquat	1.90	39.83	1.2	30.4	73	70	74
Endothall	8.62	4.39	1.5	26.8	41	23	60
2 4-D	1.17	30.00	8.0	45.0	84	61	114
Giyphosate	0.10	0.04	1.4	51.0	53	14	105
Bti	0.09	0.01	1.4	20.0	22	6	43
Esfenvalerate[d]	6.55	4.39	219.3	126.7	357	154	695
Methyl parathion[d]	31.32	286.73	100.0	90.0	508	534	460
Pyrethrins[d]	0.88	1.37	11.9	100.4	115	34	22

[a]From Lynch, S. and C. Benbrook. WWF/WPVGA Collaboration For Pesticide Risk Reduction Background and First-Results. Integrated Pest Management Measurement Systems Workshop. www.farmiandinfo.or~/caehM/sp98-1 /ipmbenb.htm.
[b]Higher Values Represent Higher Toxicities.
[c]Weighted Sums of Indices as indicated per reference above.
[d]Not used for permitted aquatic applications in New Jersey.

Table 3

Statewide 1999 Totals					
Active Ingredient	**Acres**	**Quantity**	**Units**	**Lbs ai**	**Lbs ai/A**
2,4-D[a]	33.50	3,153.00	lbs	599.07	17.88
Cu[b] Total	2,744.92			5,618.83	
Cu[b] liquid	2,564.78	6,173.93	gals	5,612.10	2.19
Cu[b] solid	180.14	183.53	lbs	6.73	0.04
$CuSO_4$	20,973.66	121,323.10	lbs	120,109.87	5.73
Diquat[c]	2,241.10	2,785.22	gals	5,570.44	2.49
Endothall[a] Total	370.63			3,104.31	
Endothall[a] liquid	354.73	1,029.56	gals	3,088.68	8.71
Endothall[a] solid	15.90	217.07	lbs	15.63	0.98
Fluridone Total	3,901.30			1,952.21	
Fluridone liquid	3,452.61	456.10	gals	1,824.40	0.53
Fluridone solid	448.69	2,556.18	lbs	127.81	0.28
Glyphosate[a]	1,207.80	703.99	gals	3,801.55	3.15
Totals	**31,472.91**			**140,756.27**	**4.47**
[a]Active ingredients expressed as acid equivalents.					
[b]Active ingredient expressed as elemental copper.					
[c]Active ingredient expressed as the cation.					

ATLANTIC					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	10.00	750.00	lbs	142.50	14.25
Cu Total	25.38	62.60	gals	56.90	
Cu Liquid	25.38	62.60	gals	56.90	2.24
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	0.25	6.00	lbs	5.94	23.76
Diquat	32.90	54.50	gals	109.00	3.31
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00

BERGEN					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.50	100.00	lbs	19.00	38.00
Cu Total	75.56			176.07	
Cu Liquid	67.88	193.07	gals	175.50	2.59
Cu Solid	7.68	15.43	lbs	0.57	0.07
$CuSO_4$	9,849.55	44,911.00	lbs	44461.89	4.51
Diquat	46.35	41.30	gals	82.60	1.78
Endothall Total	10.25			702.00	
Endothall Liquid	10.25	234.00	gals	702.00	68.49

Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	0.00	0.00		0.00	
Fluridone Liquid	0.00	0.00		0.00	0.00
Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	465.50	235.00	lbs	1269.00	2.73
Totals	**534.03**			**1583.34**	**2.96**

Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	92.46			89.96	
Fluridone Liquid	92.46	22.49	gals	89.96	0.97
Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	95.51	72.40	gals	390.96	4.09
Totals	**10,170.18**	**45589.69**		**45922.48**	**4.52**

BURLINGTON					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	87.95			114.23	
Cu Liquid	87.95	125.67	gals	114.23	1.30
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	21.10	181.71	lbs	179.89	8.53
Diquat	91.65	136.54	gals	273.08	2.98
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	422.65			650.53	
Fluridone Liquid	420.65	162.32	gals	649.28	1.54
Fluridone Solid	2.00	25.00	lbs	1.25	0.63
Glyphosate	1.79	1.28	gals	6.91	3.86
Totals	**625.14**			**1224.65**	**1.96**

CAMDEN					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	9.03			15.99	
Cu Liquid	9.03	17.59	gals	15.99	1.77
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	9.05	74.00	lbs	73.26	8.10
Diquat	16.65	32.30	gals	64.60	3.88
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	26.85			9.36	
Fluridone Liquid	5.85	1.09	gals	4.36	0.75
Fluridone Solid	21.00	100.00	lbs	5.00	0.24
Glyphosate	9.01	6.82	gals	36.83	4.09
Totals	**70.59**			**200.04**	2.83

CAPE MAY					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	9.50			13.86	
Cu Liquid	9.50	15.25	gals	13.86	1.46
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	0.00	0.00		0.00	0.00
Diquat	0.00	0.00		0.00	0.00
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	1.00			1.00	
Fluridone Liquid	1.00	0.25	gals	1.00	1.00
Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	4.49	3.10	gals	16.74	3.73
Totals	**14.99**			**31.60**	**2.11**

CUMBERLAND					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	0.00	0.00		0.00	
Cu Liquid	0.00	0.00		0.00	0.00
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	0.00	0.00		0.00	0.00
Diquat	0.00	0.00		0.00	0.00
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	0.00	0.00		0.00	
Fluridone Liquid	0.00	0.00		0.00	0.00
Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	94.93	65.55	gals	353.97	3.73
Totals	**94.93**			**353.97**	**3.73**

ESSEX					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	9.74			18.87	
Cu Liquid	8.90	18.96	gals	17.23	1.94
Cu Solid	0.84	44.70	lbs	1.64	1.95
$CuSO_4$	643.88	9172.75	lbs	9081.02	14.10
Diquat	35.35	17.97	gals	35.94	1.02
Endothall Total	7.00			22.50	
Endothall Liquid	7.00	7.50	gals	22.50	3.21
Endothall Solid	0.00	0.00	lbs	0.00	0.00
Fluridone Total	30.56			7.16	
Fluridone Liquid	30.56	1.79	gals	7.16	0.23

GLOUCESTER					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	38.90			50.94	
Cu Liquid	38.90	56.04	gals	50.94	1.31
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	79.15	551.88	lbs	546.36	6.90
Diquat	82.08	125.25	gals	250.50	3.05
Endothall Total	20.00			150.00	
Endothall Liquid	20.00	50.00	gals	150.00	7.50
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	0.60			2.00	
Fluridone Liquid	0.60	0.50	gals	2.00	3.33

Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	2.00	1.50	gals	8.10	4.05
Totals	**728.53**			**9173.60**	**12.59**

Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	41.25	30.93	gals	167.02	4.05
Totals	**261.98**			**1166.82**	**4.45**

HUDSON					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	89.60			161.80	
Cu Liquid	89.60	178.00	gal	161.80	1.81
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	0.00	0.00		0.00	0.00
Diquat	39.60	78.00	gal	156.00	3.94
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	82.00			62.20	
Fluridone Liquid	66.00	15.50	gal	62.00	0.94
Fluridone Solid	16.00	4.00	lbs	0.20	0.01
Glyphosate	0.00	0.00		0.00	0.00
Totals	**211.20**			**380.00**	**1.80**

HUNTERDON					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	31.47			67.49	
Cu Liquid	31.47	74.25	gals	67.49	2.14
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	37.23	332.29	lbs	328.97	8.84
Diquat	5.18	6.15	gals	12.30	2.37
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	11.70			24.08	
Fluridone Liquid	11.04	5.77	gals	23.08	2.09
Fluridone Solid	0.73	20.03	lbs	1.00	1.37
Glyphosate	0.00	0.00		0.00	0.00
Totals	**85.58**			**432.84**	**5.06**

MERCER					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	41.85			81.34	
Cu Liquid	41.85	89.48	gals	81.34	1.94
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	4.55	38.40	lbs	38.02	8.36
Diquat	1.50	2.50	gals	5.00	3.33
Endothall Total	10.71			0.54	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	10.71	7.50	lbs	0.54	0.05
Fluridone Total	3.87			2.76	
Fluridone Liquid	3.87	0.69	gals	2.76	0.71
Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	0.00	0.00		0.00	0.00
Totals	**62.48**			**127.65**	**2.04**

MIDDLESEX					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	34.93			43.75	
Cu Liquid	34.93	48.13	gals	43.75	1.25
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	5.16	44.00	lbs	43.56	8.44
Diquat	8.35	12.30	gals	24.60	2.95
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	7.40			6.04	
Fluridone Liquid	7.40	1.51	gals	6.04	0.82
Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	12.97	5.26	gals	28.40	2.19
Totals	**68.81**			**146.35**	**2.13**

MONMOUTH					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	1405.95			3421.73	
Cu Liquid	1405.95	3764.28	gals	3421.73	2.43
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	549.08	2062.20	lbs	2041.58	3.72
Diquat	16.07	30.49	gals	60.98	3.79
Endothall Total	42.50			255.00	
Endothall Liquid	42.50	85.00	gals	255.00	6.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	14.43			14.04	
Fluridone Liquid	14.43	3.51	gals	14.04	0.97
Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	0.00	0.00		0.00	0.00
Totals	**2028.03**			**5793.33**	**2.86**

MORRIS					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	239.30			708.20	
Cu Liquid	229.91	778.78	gals	707.91	3.08
Cu Solid	9.39	7.85	lbs	0.29	0.03
$CuSO_4$	2,463.19	16,641.95	lbs	16475.53	6.69
Diquat	549.47	797.47	gals	1594.94	2.90
Endothall Total	44.59			287.37	
Endothall Liquid	40.75	90.80	gals	272.40	6.68
Endothall Solid	3.84	207.95	lbs	14.97	3.90
Fluridone Total	1,424.74			397.61	
Fluridone Liquid	1,401.04	96.14	gals	384.56	0.27
Fluridone Solid	23.70	261.05	lbs	13.05	0.55
Glyphosate	17.12	12.83	gals	69.28	5.40
Totals	**4,738.41**			**19532.94**	**4.12**

OCEAN					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	29.88			56.59	
Cu Liquid	29.88	62.25	gals	56.59	1.89
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	36.10	232.00	lbs	229.68	6.36
Diquat	28.98	43.30	gals	86.60	2.99
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	151.00			48.50	
Fluridone Liquid	0.00	0.00		0.00	0.00
Fluridone Solid	151.00	970.00	lbs	48.50	0.32
Glyphosate	0.00	0.00		0.00	0.00

PASSAIC					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	283.05			106.99	
Cu Liquid	211.80	116.80	gals	106.17	0.50
Cu Solid	71.25	22.25	lbs	0.82	0.01
$CuSO_4$	2,072.20	16,745.95	lbs	16578.49	8.00
Diquat	335.48	315.63	gals	631.26	1.88
Endothall Total	23.63			195.39	
Endothall Liquid	23.63	65.13	gals	195.39	8.27
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	555.30			161.08	
Fluridone Liquid	546.30	39.02	gals	156.08	0.29
Fluridone Solid	9.00	100.00	lbs	5.00	0.56
Glyphosate	25.60	17.45	gals	94.23	3.68

Totals	245.96			421.37	1.71

Totals	3,295.26			17767.44	5.39

SALEM					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	0.00	0.00		0.00	
Cu Liquid	0.00	0.00		0.00	0.00
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	240.00	1,900.00	lbs	1881.00	7.84
Diquat	0.00	0.00		0.00	0.00
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	0.00	0.00		0.00	
Fluridone Liquid	0.00	0.00		0.00	0.00
Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	268.72	162.09	gals	875.29	3.26
Totals	**508.72**			**2756.29**	**5.42**

SOMERSET					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	64.11			153.27	
Cu Liquid	63.77	167.81	gals	152.54	2.39
Cu Solid	0.34	20.00	lbs	0.73	2.16
$CuSO_4$	143.19	880.27	lbs	871.47	6.09
Diquat	20.29	36.91	gals	73.82	3.64
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	56.22			68.48	
Fluridone Liquid	56.22	17.12	gals	68.48	1.22
Fluridone Solid	0.00	0.00		0.00	0.00
Glyphosate	0.00	0.00		0.00	0.00
Totals	**283.81**			**1167.04**	**4.11**

SUSSEX					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	23.00	2,300.00	lbs	437.00	19.00
Cu Total	215.35			220.43	
Cu Liquid	124.85	239.88	gals	218.05	1.75
Cu Solid	90.50	64.90	lbs	2.38	0.03
$CuSO_4$	4,727.83	27,145.12	lbs	26873.67	5.68
Diquat	882.30	983.27	gals	1966.54	2.23
Endothall Total	204.95			1472.64	
Endothall Liquid	204.95	490.88	gals	1472.64	7.19
Endothall Solid	0.00	0.00	lbs	0.00	0.00
Fluridone Total	997.42			354.87	
Fluridone Liquid	775.30	75.72	gals	302.88	0.39
Fluridone Solid	222.12	1,039.70	lbs	51.99	0.23

UNION					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	6.36			20.00	
Cu Liquid	6.36	22.00	gals	20.00	3.14
Cu Solid	0.00	0.00		0.00	0.00
$CuSO_4$	76.40	282.62	lbs	279.79	3.66
Diquat	16.53	26.17	gals	52.34	3.17
Endothall Total	1.35			0.12	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	1.35	1.62	lbs	0.12	0.09
Fluridone Total	1.55			4.16	
Fluridone Liquid	1.55	1.04	gals	4.16	2.68
Fluridone Solid	0.00	0.00		0.00	0.00

Glyphosate	160.20	81.83	gals	441.88	2.76
Totals	**7,211.05**			**31767.03**	**4.41**

Glyphosate	6.71	4.13	gals	22.30	3.32
Totals	**108.90**			**378.71**	**3.48**

WARREN					
Active Ingredient	**Acres**	**Amount**		**Lbs ai**	**Lbs ai/A**
2,4-D	0.00	0.00		0.00	0.00
Cu Total	47.03			130.39	
Cu Liquid	46.89	143.10	gals	130.08	2.77
Cu Solid	0.14	8.40	lbs	0.31	2.20
$CuSO_4$	15.77	120.96	lbs	119.75	7.59
Diquat	32.41	45.18	gals	90.36	2.79
Endothall Total	0.00	0.00		0.00	
Endothall Liquid	0.00	0.00		0.00	0.00
Endothall Solid	0.00	0.00		0.00	0.00
Fluridone Total	21.49			49.86	
Fluridone Liquid	18.34	12.01	gals	48.04	2.62
Fluridone Solid	3.15	36.40	lbs	1.82	0.58
Glyphosate	1.72	3.62	gals	19.55	11.37
Totals	**118.42**			**409.90**	**3.46**

Issue: Petroleum Spills
Author: Tristan Gillespie
Version:05/31/00

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
	Petroleum Spills
Stressor	Spilled oil can pose serious threats to the marine and alluvial environments. The severity of impact of an oil spill depends on a variety of factors, including characteristics of the oil itself. Large spills of refined petroleum products such as gasoline evaporate quickly and may cause only short-term environmental effects. On the other hand, crude oils, heavy fuel oils, food-based oils such as nut based, vegetable and fruit based oils, and water-in-oil mixtures may cause widespread and long-lasting physical contamination of shorelines. Natural conditions, such as water temperature, current and wave action, and weather, also influence the behavior of oil in the different environments
Description of stressor	The term *oil* describes a broad range of natural *hydrocarbo*n-based substances and refined petroleum products. (Hydrocarbons are chemical compounds composed of the elements *hydrogen* and *carbo*n.) Most refined petroleum products are mixtures of many types of hydrocarbon-based substances. Commonly used products refined from crude oil include fuel oil, gasoline, kerosene, and jet fuel. Each type of crude oil and refined product has distinct physical and chemical properties. These properties affect the way oil will spread and break down. The hazardous conditions presented by these properties may pose a serious threat to aquatic, marine and human life, as well as natural and man-made resources. The rate at which an oil spill spreads will determine its effect on a particular environment. Most oils tend to spread horizontally into a smooth and slippery surface, called a *slic*k, on top of the water. Factors, which affect the ability of an oil spill to spread, include *surface tension, specific gravit*y, and *viscosit*y. *Surface tension* is the measure of attraction between the surface molecules of a liquid. The higher the oil's surface tension, the more likely a spill will remain in place. If the surface tension of the oil is low, the oil will spread even without help from wind and water currents. Because increased, temperatures can reduce a liquid's surface tension, oil is more likely to spread in warmer waters than in very cold waters. *Specific gravity* is the density of a substance compared to the density of water. Since most oils are lighter than water, they float on top of it. However, the specific gravity of an oil spill can increase if the lighter substances within the oil evaporate. *Viscosity* is the measure of a liquid's resistance to flow. The higher the viscosity of the oil, the greater the tendency for it to stay in one place. (Honey is an example of a *highly viscous* liquid.) It is also important to note that as an oil weathers, the lighter constituents evaporate off and the remainder of the oil tends to adsorb onto the particles suspended in the water column forcing the oil to sink. As this happens damage to shorelines is expanded to areas under the surface of the water. The sinking potential and adsorption rate of the oil is primarily dependant on the turbidity of the water and the ionization potential of the oil. The oils are not particular about adsorbing to silica-based sediment or biological sediment.

Stressor-specific impacts considered: Biological integrity, Habitat/ecosystem health, Ecosystem function	After oil is spilled, the most toxic substances in it evaporate quickly. Therefore, plant, animal, and human exposure to the most toxic substances are reduced rapidly with time, and are usually limited to the initial spill area. Although some organisms may be seriously injured or killed very soon after contact with the oil in a spill *(lethal effect*s), non-lethal toxic effects are subtler and often longer lasting. For example, marine life on reefs and shorelines is at risk of being smothered by oil that washes ashore or of being slowly poisoned or suffocated by long-term exposure to oil trapped in shallow water or on beaches. As the oil weathers and sinks into the water column the food-chain can be seriously damaged making it difficult for the ecosystem to recover. *Shellfish:* Adult crab and lobster might be impacted by an oil spill, especially by a large spill or a light oil type. With the more shallow water (usually less than 6 feet) associated with the oyster beds, a petroleum spill of any size could result in uptake of petroleum hydrocarbons in oyster tissues, but usually not in concentrations sufficient to cause mortality. Tainting of oysters and clams would be a major concern in the areas where harvesting was allowed. The most sensitive time is when larvae and juveniles are present. The larval and juvenile stages of shellfish are 10 to 100 times more sensitive to pollutants than the adult stage. *Finfish:* The primary concern of oil spills and finfish is not only toxicity to fish, but the possibility of human exposure through the consumption of contaminated fish. The levels of oil in the water from a spill of crude oil or heavy refined products in the waterways would not be sufficient for acute toxicity to adult finfish. Toxicity occurs at levels of 1-10 parts per million (ppm), which is about the maximum water solubility. Therefore, dilution rapidly lowers the concentration below short-term toxic levels. It is possible, however, for fish to uptake petroleum hydrocarbons either through direct exposure or through eating contaminated food, and for the flesh of the fish to become tainted, thus making it unpalatable for humans. Like shellfish, larval fish are usually much more sensitive to toxicity from pollutants than the adults. During spawning seasons the fry populations can be destroyed when floating oil, regardless of thickness, coats the surface of the water which either inhibits the fry's ability to breathe or forces them to directly ingest the oil while attempting to breathe. *Birds*: In general, birds are highly susceptible to oil spill impacts, although there are significant differences in the likelihood of contamination occurring to the various groups. Birds can be divided into the following behavioral groups: wading birds feed on fish and crustaceans in the shallow waters of estuaries by wading into the water. Their long legs and long beaks are adapted for this type of behavior, so they do not need to get their feathers wet when feeding. Wading birds are not likely to be impacted heavily by an oil spill, unless the marshes in the areas where they live and feed become oiled. The birds will get contaminated from the marsh grass. Oil spills can, however, impact their food source. Shorebirds are found mostly on sand beaches. They are not likely to be contaminated, because they remain at the edge of the water and feed on animals living in the beach sand. However, birds such as pipers, plovers, knots and terns which feed in the wet sands and shallow tidal pools must penetrate the surface of the water or contaminated sand surfaces to acquire their prey. The method of predation, causes them to directly ingest the oil while pecking into the sands, experience shows that the birds tend to ignore the oil and continue to feed.
	Seabirds are likely to be contaminated by a pollutant because they feed in open waters and dive for food below the

	water surface. The large number of gulls in the area make them likely victims of a spill as well as pelicans and Cormorants which are attracted by the surface smoothing effect of the oil. Waterfowl feed on small crustaceans, fish, and aquatic vegetation. They spend much or their time resting on the water and are very likely to be oiled, even from small spills. The effect of oil on waterfowl is a loss of insulation from oiled feathers, usually causing the birds to die from exposure to the cold water. The heavier oils will coat the feathers of exposed waterfowl hindering their ability to fly. This makes them more susceptible to predation, which contaminates the predator as well. There can be large numbers of waterfowl in a relatively small area, especially during migrations. However, other than small isolated populations, waterfowl do not generally breed in the area, so the greatest impacts would be during winter and migrations.
Key impacts selected (critical ecological effects)	Oil spills have the potential to severely impact biological integrity, habitat/ecosystem health, and ecosystem function.
Exposure routes and pathways considered	Direct exposure to organisms involves direct ingestion (e.g., of oil during preening), absorption, and inhalation of vapors. Indirect exposure includes ingesting contaminated prey items. Ecosystems are directly exposed by the adsorption and absorption of spilled petroleum onto organic and inorganic surfaces. Most spills occur in Newark bay, Arthur Kill, Kill Van Kull, and the Delaware River. Spills also occur in inland freshwater streams, but to a much smaller extent. *Newark Bay:* Includes the waterfronts of the Passaic and Hackensack Rivers. There are several points of concern including Shooters Island, which is an important nesting area for wading birds. Marshes occur in various areas, particularly along the Hackensack River. If a pollution incident were to occur near these areas, there would be little time to initiate protection procedures. Tidal currents would quickly spread a slick throughout Newark Bay, with the winds determining which shoreline would have the heaviest impact. With the large amount of covered docks and piers, spilled product could accumulate under these structures, hampering cleanup and recovery efforts. *Delaware River:* The Delaware River shoreline in the vicinity of Philadelphia is dominated by man-made structures. There are several short sections of sand and gravel beach, especially south of Philadelphia, but sensitive areas are largely restricted to the smaller tidal creeks associated with the river. These tidal creeks are larger and more abundant along the southern shore of the Delaware River. Extensive salt marshes and fresh to brackish water swamps are associated with many of these tidal creeks. Darby Creek, Little Tinicum Island, Chester Island, Cedar Swamp, and Oldmans Creek are the most sensitive of these. Except for the islands within the Delaware River, most of the sensitive areas can be protected relatively easily by the placement of booms and skimmers at narrow creek mouths. Due to the many habitat types and moderate species diversity in the Philadelphia region, there are many species that can be affected by even small spills of hazardous chemicals and petroleum products. The susceptibility of each animal group depends on species-specific responses to the substance, physical properties of the spilled material, duration of exposure, and seasonal considerations, such as variations in the distributions and concentration of wildlife as well as differential sensitivities of various life stages. In addition, there may secondary effects as local food webs are perturbed or altered by contaminants.
	Pea Patch Island, located in the lower Delaware River, is the largest heronry on the east coast. Oil tanker trucks sometimes spill their cargo. In addition, people who change their own oil often dump their used oil into public sewers. Inland oil spills happen less frequently and often involve a smaller amount of oil. However, because inland lakes and

	streams are protected from tidal waves, they are more vulnerable to oil pollution because there is no natural washing or dilution taking place. Marinas on lakes, such as that at Lake Hopatcong, are invariably sources of oil pollution. Also, 2-cycle engines, such as those used in jet skis release a significant portion of their fuel directly into the water. More research needs to be done on this particular source of pollution in New Jersey. The Passaic and Hackensack Rivers also have significant boat/barge traffic and subsequent oil pollution. Again, the amount of oil pollution in these ecosystems needs to be investigated further. Both industrial and domestic Underground Storage Tanks for heating fuel and gasoline for cars sometimes leak as well. They migrate into the groundwater and stormwater sewer systems and eventually migrate into local streams and rivers.
Population(s)/ecosystem(s) exposed statewide	Marine waters and associated shellfish, finfish, and aquatic birds are most directly affected by oil spills. Wetlands and inland waters can also be affected. Oil spills are not frequent in terrestrial ecosystems such as forests or recreational areas, nor do they pose a significant threat in those ecosystems. When oil does spill in these ecosystems, they often do not spread as far or as fast as they would in an aquatic environment.
Quantification of exposure levels statewide	From Newark Bay to Sandy Hook, roughly 600 spills occur each year. The average spill is less than 10 gallons. Roughly the same number and size spills occur from Sandy Hook, along the Jersey shore and up the Delaware River.
Specific population(s) at increased risk	Marine and aquatic shellfish, finfish, and birds are most directly effected by oil spills.
Quantification of exposure levels to population(s) at increased risk	From Newark Bay to Sandy Hook, roughly 600 spills occur each year. The average spill is less than 10 gallons. Roughly the same number and size spills occur from Sandy Hook, along the Jersey shore and up the Delaware River. The small spills have a small effect. The major spills have a large effect. In the past three years, there has been 11 major oil spills in NJ. Major means more than 500 gallons.
Quantitative impact-assessment employed	USCG Lieutenant Jeannot Smith, NY-NJ Harbor and USCG Lieutenant Commander Dave Ford, Jersey Shore and Delaware River are notified of every spill along New Jersey's shores. They provided a detailed list of every spill in their respective territories since 1992. (See attached)

Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score

Assessment of severity/irreversibility
 	
5 - Lifeless ecosystems or fundamental change;
Irreversible
4 - Serious damage:
$ many species threatened/endangered
$ major community change
$ extensive loss of habitats/species
Long time for recovery
3 - Adverse affect on structure and function of system:
$ all habitats intact and functioning
$ population abundance and distributions reduced
Short time for recovery
2 - Ecosystem exposed but structure and function hardly
affected
1 - No detectable exposure
	Major oil spills are infrequent, but have a large environmental impact. Minor oil spills happen much more frequently and may have a significant cumulative impact. In the six shoreline ecosystems examined (Arthur Kill, Hudson River, Kill Van Kull, Newark Bay, Jersey Shore, and Delaware River), after cleanup efforts, there was an annual average total spillage of 19,450 gallons of petroleum oil.	3

Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 B Occasional 2 B Rare 1 - Possible in the future 0 B Unlikely (or 0.1)		Small oil spills = 4 Major oil spills = 3

Issue: Petroleum Spills
Author: Tristan Gillespie
Version:05/31/00

Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	All of New Jersey's coasts are affected. Most of New Jersey's inland waters and wetlands are affected too.	2
	Total	18-24

Assessment of uncertainties in this assessment (H,M,L) and brief description	The affects of oil spills on aquatic and shoreline ecosystems and associated aquatic life/wildlife *are* well-known. However, more research is needed to determine the relative risk between an ecosystem in which small spills occur regularly versus one in which large spills occur very infrequently. Some experts in this field claim that ecosystems in which small spills occur regularly, like the Arthur Kill, are more adversely affected. The rationale is that with a steady influx of pollution, an ecosystem will adapt to the pollution and thus become changed entirely. An ecosystem that receives one large oil spill can recover almost entirely over time to its original state (like Prince William Sound). Other experts contend that marine ecosystems can absorb small quantities of oil at a time, but do not have the capacity to recover from a complete smothering as would occur with a large oil spill. Clearly, more research is needed in this area. (M)
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	It is unlikely that additional data will change the risk estimate. (L)
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, !, =, ≡; where + is improvement), and brief description.	(+): Based on improvements in ship design and recent emphasis on reducing oil spills, the near future looks positive. It is possible that in the time frame beyond 10 years, we will no longer use petroleum oil. We may be using more environmentally friendly sources of energy. It is also possible that the technology for oil transport, transfer, and/or spill cleanup improves to the point at which no oil is released significantly reduces the risk from this stressor. (++ beyond 10 years).
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	(H): There is a high level of use of NJ's waters by ships/barges containing oil (e.g., Arthur Kill, Delaware River). The Delaware River is the 3rd largest importer of crude oil in the country and the 5th largest in the world. With the width of the river and the amount of ship and barge traffic up and down the river the likelihood of a collision is high. Also, with the number of refineries and other production facilities along the both sides of the river the possibilities of an onshore spill and/or a loading/unloading accident occurring is not only high but probable, in spite of the precautions and regulations in place
Link to other Work Groups (e.g., socioeconomic impacts)	The Socio-economic workgroup should examine the attached table of Oil Spills Involving The Office of Natural Resource Damages. This documents oil spills in New Jersey since 1986, the ecosystems injured, and the Dollar settlements from the subsequent lawsuits.

	The Human Health group could trace the oil in the food web and see how it affects humans.
Extent to which threat is currently regulated or otherwise managed	The US Coast Guard is the front line defense in monitoring, regulating and fighting oil spills. NJDEP is the frontline in remediating the spills and reclaiming damages from guilty parties. EPA regulates and enforces all facilities with stored oil volumes of greater than 660 gallons in a single tank or total combined storage greater than 1000 gallons above ground and/or 42,000 gallons underground. EPA is to be notified of any spill creating a sheen on a navigable surface water in their jurisdiction. However, EPA generally does not respond to spills less than 500 gallons that threaten a surface water unless the surface water was directly impacted. The NJDEP facilitates the clean-up of the smaller spills but directly coordinates with an EPA federal on-scene coordinator as required by the National Contingency Plan. EPA is directly involved with the planning of oil spill prevention and response strategies with the state and local authorities. EPA handles and/or coordinates all of the inland river and stream spills utilizing all of the state and local assets available. Local oil handlers (e.g., refineries and retailers) are required to have oil spill response ability also (e.g., supplies, contractors).
Barriers to restoration	Once oil is spilled, it spreads everywhere. It is impossible to effectively clean all surfaces and places in which the oil spreads. Sometimes the cleaning process itself is more harmful and abrasive than simply letting the ecosystem absorb the oil naturally.
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources{tc \l1 "NJ Primary Sources}	
Large business/industry	H: Oil transport, lightering, and transfer
Transportation	M: Oil tanker trucks sometimes spill their cargo. In addition, people who change their own oil often dump their used oil into public sewers.
Residential	L
Agriculture Recreation	L M: Jet Skis release a significant portion of their fuel directly into the water. 2-Cycle marine engines release oil to the water in the exhaust.

Resource extraction	L: Very little oil is drilled in New Jersey .
Government	L
Natural sources/processes	L
Orphan contaminated sites	M: Underground Storage Tanks sometimes leak oil.
Diffuse Sources{tc \l1 "Diffuse Sources}	
Sediment sinks	L
Soil sinks	L
Non-local air sources incl. Deposition	L
Biota sinks	L

<u>Oil Spill Summary</u>

Spilled oil can pose serious threats to the marine and alluvial environments. The severity of impact of an oil spill depends on a variety of factors, including characteristics of the oil itself. Large spills of refined petroleum products such as gasoline evaporate quickly and may cause only short-term environmental effects. On the other hand, crude oils, heavy fuel oils, food-based oils such as nut based, vegetable and fruit based oils, and water-in-oil mixtures may cause widespread and long-lasting physical contamination of shorelines. Natural conditions, such as water temperature, current and wave action, and weather, also influence the behavior of oil in the different environments. Direct exposure to organisms involves direct ingestion (e.g., of oil during preening), absorption, and inhalation of vapors. Indirect exposure includes ingesting contaminated prey items. Ecosystems are directly exposed by the adsorption and absorption of spilled petroleum onto organic and inorganic surfaces.

Most spills occur in Newark bay, Arthur Kill, Kill Van Kull, and the Delaware River. Spills also occur in inland freshwater streams, but to a much smaller extent. Both industrial and domestic Underground Storage Tanks for heating fuel and gasoline for cars sometimes leak as well. They migrate into the groundwater and stormwater sewer systems and eventually migrate into local streams and rivers.

Marine waters and associated shellfish, finfish, and aquatic birds are most directly affected by oil spills. Wetlands and inland waters can also be affected. Oil spills are not frequent in terrestrial ecosystems such as forests or recreational areas, nor do they pose a significant threat in those ecosystems. When oil does spill in these ecosystems, they often do not spread as far or as fast as they would in an aquatic environment.

Major oil spills are infrequent, but have a large environmental impact. Minor oil spills happen much more frequently and may have a significant cumulative impact. In the six shoreline ecosystems examined (Arthur Kill, Hudson River, Kill Van Kull, Newark Bay, Jersey Shore, and Delaware River), after cleanup efforts, there was an annual average total spillage of 19,450 gallons of petroleum oil. Therefore, due to the relatively high frequency of oil spills in NJ, difficulty to clean-up and their long-lasting effects, the total score and average scores are moderate.

Issue: Petroleum Spills
Author: Tristan Gillespie
Version:05/31/00
Statewide Analysis of Threat *Threat = Oil Spills*

Ecosystem	Severity Irreversibility	Frequency	Magnitude	Score
Inland Waters	3	3	3	27
Marine Waters	3	4	3	36
Wetlands	4	3	4	48
Forests	1	1	1	1
Grasslands	1	1	1	1
			Total Score	113
			Average Score (Total ÷ 5)	22.6

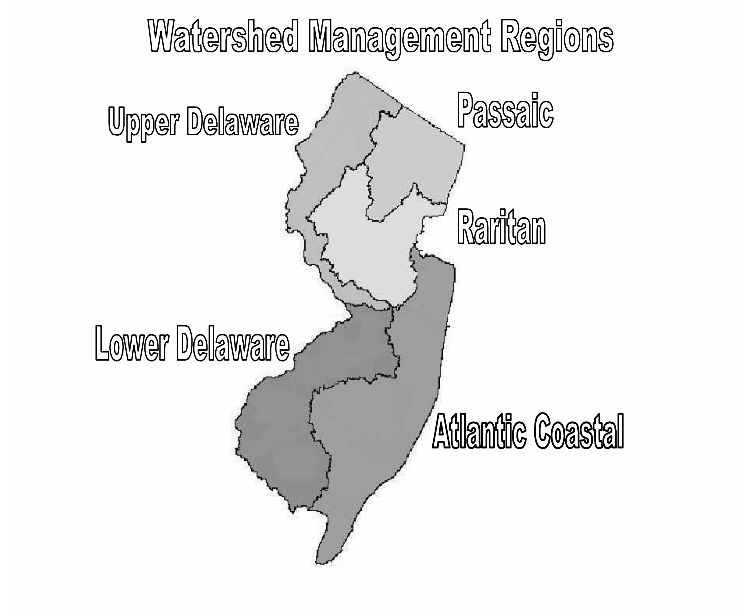
Risk by Watershed Management Region

THREAT = Oil Spills	ECOSYSTEM *Note: letter in column is current risk; letter in parenthesis is potential risk if introduced*				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	L	NA	L	L	L
Passaic	M	M	M	L	L
Raritan	H	H	H	L	L
Atlantic					

Issue: Petroleum Spills
Author: Tristan Gillespie
Version:05/31/00

	M	M	M	L	L
Lower Delaware	M	M	M	L	L
Region/Watershed (secondary)					
Urban	H	H	H	L	L
Suburban	M	M	M	L	L
Rural	M	M	M	L	L

H=high, M=medium, L=low, NA = not applicable.



Issue: Pets as Predators
Author: Tim Casey
Version: 03/02/01

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Pets as Predators**
Description of stressor	Free ranging cats are abundant predators. Although rural free ranging cats have greater access to wildlife, urban house pets are effective predators when allowed outdoors. The combined total of pets and free ranging cats in the US probably exceed 100 million (Coleman et al, 1997). Extensive study of their feeding habits indicates that approximately 70% of their diet is small mammals and about 20% is birds (Fitzgerald (1988). Extensive studies in Wisconsin suggest that cats kill 39 million birds per year in that state. A predation study in Virginia reported 28 kills per urban pet cat and 91 kills per rural pet cat (Mitchell and Beck, 1992).
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Biodiversity. Pets are known predators on a number of endangered species of birds, mammals and reptiles. In New Jersey they are a significant problem for shore nesting birds (Jenkins, personal communication). Cats frequently outnumber native predators and can outcompete them when prey resources are low (George, 1974).
Key impacts selected (critical ecological effects)	
Exposure Assessment	
Exposure routes and pathways considered	
Population(s)/ecosystem(s) exposed statewide	Small perching birds (passerines) are at risk from pet predation. Beach nesting birds such as piping plover and tern are particularly vulnerable to feral and domestic dogs and cats (Burger and Gochfeld 1991). Studies demonstrate that cats outnumber and outcompete some native predators such as hawks and weasels
Quantification of exposure levels statewide	Quantitative data are not available in New Jersey
Specific population(s) at increased risk	Least Tern and Piping Plover (Burger and Gochfeld, 1991)
Quantification of exposure levels to population(s) at increased risk	Not available for New Jersey. Results for this template are extrapolated from results of studies from other states.
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	N/A
Risk Characterization	

Issue: Pets as Predators
Author: Tim Casey
Version: 03/02/01

Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score
Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	Difficult to assess due to lack of quantitative data for any region of New Jersey.	2
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Although a highly urban state, New Jersey undoubtedly has a large number of free ranging as well as domestic pets.	4
Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	Problematic due to lack of data	1
	Total	8

Issue: Pets as Predators
Author: Tim Casey
Version: 03/02/01

Assessment of uncertainties in this assessment (H,M,L) and brief description	H: No systematic study of the problem is available for New Jersey. Although predators are cited as the major cause in decline of nesting success in piping plovers, management for control of dogs and cats by NJDEP Endangered and Non Game Species Program is recommended at only eight of 34 monitored Piping Plover breeding sites (Jenkins and Niles, 2000)
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	H – Virtually any information on pet predation in New Jersey would be beneficial in our understanding of the degree of risk to our wildlife.
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, !, =, ≡; where + is improvement), and brief description.	Habitat destruction caused by urban sprawl exacerbates the problem by increasing the incidence of pets while decreasing preferred habitat for prey species. + Increased education by non profit groups such as the American Bird Conservancy's Cats Indoors! The campaign for safer birds and cats.
Potential for catastrophic impacts (H,M,L) and brief description	L - This is an ongoing problem which is unlikely to increase dramatically
Link to other Work Groups (e.g., socioeconomic impacts)	None are obvious
Extent to which threat is currently regulated or otherwise managed	This area is not currently regulated by the NJDEP or Public Health.
Barriers to restoration	N/A
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	
Large business/industry	N/A
Small business industry	N/A
Transportation	N/A
Residential	M - Urban and suburban cats add to the toll taken by rural cats (Coleman et al, 1997)
Agriculture	H - Rural cats (both free ranging and domestic) are responsible for killing over a billion small mammals and hundreds of million birds annually(Coleman et al 1997)
Recreation	M - Recreation sites are prime breeding habitat for some shorebirds. Pets, habitat disruption and human disturbance are implicated in declining shorebird numbers (Burger and Gochfeld, 1994).
Resource extraction	N/A
Government	N/A
Natural sources/processes	N/A
Orphan contaminated sites	N/A

Diffuse Sources	
Sediment sinks	N/A
Soil sinks	N/A
Non-local air sources incl. deposition	N/A
Biota sinks	N/A

Issue: Pets as Predators
Author: Tim Casey
Version: 03/02/01

Statewide Analysis of Threat Threat = Pets as predators

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters				
Marine Waters				
Wetlands				
Forests				
Grasslands				
			Total Score	
			Average Score (total ÷ 5)	

Risk by Watershed Management Region

THREAT = Pets as Predators	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware		NA			
Passaic					
Raritan					
Atlantic					
Lower Delaware					
Region/Watershed (secondary)					
Urban					
Suburban					
Rural					

H=high, M=medium, L=low, NA = not applicable

Issue: Pets as Predators
Author: Tim Casey
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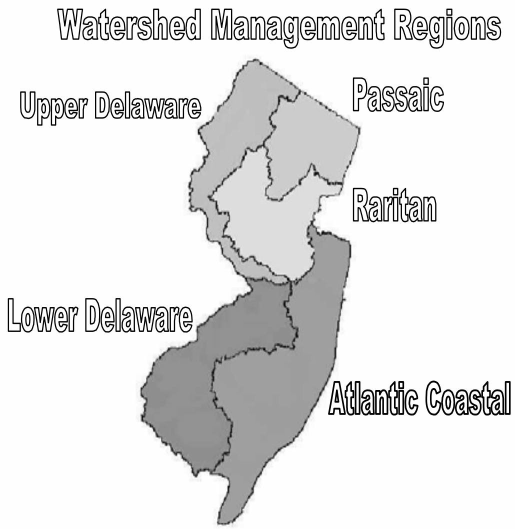

References

Anonymous (2000) Domestic cat predation on birds and other wildlife. Publication of The American Bird Conservancy. Web site: www.abcbirds .org

Burger, J. and M. Gochfeld. (1991). The Common Tern. Its breeding biology and social behavior. New York, Columbia University Press.

Burger, J. and M. Gochfeld (1994). Predation and effects of humans on island nesting birds. Birdlife Conservation Series #1: 39-67.

Coleman, J. S., S.A. Temple and S.R. Craven (1997).Cats and wildlife. A conservation dilemma. Publ. Wisc. Coop. Extension. Available on the World Wide Web at http://www.wisc.edu/wildlife/e-pubs.html.

Coleman, J. S. and S.A. Temple (1996). On the prowl. Wisc. Natr. Res. 20(6): 4-8.

Fitzgerald B. M. (1988). Diet of domestic cats and their impact on prey populations. Pp 123-147. In: D.C. Turner and P. Bateson (eds) *The Domestic Cat: The Biology of Its Behavior.* Cambridge University Press.

Jenkins, D. and L. Niles (2000). Keeping the piping plover in New Jersey's future. A synopsis of population status and a framework for piping plover recovery in New Jersey.

Mitchell, J.C. and R.A. Beck (1992) Free-ranging domestic cat predation on native vertebrates in rural and urban Virginia. Virginia Journal of Science 43: 197-207.

New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Pfiesteria** ***(Pfiesteria piscicida)***
Description of stressor	*P. piscicida* is a unicellular polymorphic toxic dinoflagellate alga that is associated with fish kills in MD, DE, VA, and NC. It is not contagious or infectious and cannot be "caught" like a flu or cold (USEPA 1999). There is no evidence that *Pfiesteria*-related illnesses are associated with the consumption of finfish, shellfish or crustaceans. Any human health problems associated with the organism are related to its release of toxins into the waterbody (USEPA, 1999). The microorganism was discovered in 1991 at a fish kill in North Carolina's Pamlico Estuary (Burkholder et al. 1995). *Pfiesteria* has 24 known life stages and its size ranges from 5-52 µm, depending upon the stage (Heinicke 1999). While *Pfiesteria* is not a source of human illness through seafood, it can cause central nervous system problems for people who directly contact it in estuarine waters (Fox 1998). It has been implicated as the causative agent of major fish kills in estuarine ecosystems in southeastern U.S. (Burkholder et al. 1995). First observed in laboratory aquaria in 1988 in NC, it has been detected in numerous environmental waters including Chesapeake Bay, Pamlico and Neuse River systems (NC), Pocomoke, Manokin and Chicamacomico Rivers and Kings Creek [MD) and Indian River (DE) (USEPA 1997) and DE inland bays (Heinicke 1999). While many fish kills have occurred in shallow, nutrient rich estuaries in watersheds dominated by large hog and poultry operations and by municipal sewage (Pelley 1998), t**here are no confirmed reports of *Pfiesteria* type fish kills in NJ waters as of 6/12/00. However, the NJDEP's Division of Science, Research & Technology sampled 32 estuarine sites within an area where there is a potential for *Pfiesteria occurrence in NJ waters. P. piscicida* of unknown toxic potential has been conclusively identified in the Tuckahoe River water and sediments using a new molecular assay (Atherholt & Ruppel, 2000). *Pfiesteria piscicida-specific DNA was detected at only one of these areas, the Tuckahoe River near Corbin City, NJ.*** *Pfiesteria* belongs to a group of at least 40 dinoflagellate algae that are known to cause fish kills and there has been an increase in this group of species in the past 15 yrs (Heinicke 1999). Requirements (Heinicke 1999): Salinity: 0-35 parts per thousand (ppt) (optimal = 15 ppt); Temp= 2--35^{0}C (optimal = 26^{0}C); phosphate and organic nitrogen can stimulate growth;
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Toxic *Pfiesteria or Pfiesteria*-like organism have been implicated as causative agents of major fish kills (affecting 10^3 to 10^9 finfish and shellfish) in estuarine/coastal waters of the mid-Atlantic and southeastern U.S. (Burkholder et al. 1997); lethal to fish at low cell densities (>250-300 toxic zoospores per mL), and at sub-lethal levels (>100 toxic zoospores per mL); cause ulcerative fish diseases. Fish kills are linked to other environmental stressors such as low dissolved oxygen in the Pocomoke Rv, (MD) and the Neuse/Pamlico estuaries (NC) (Burkholder et al. 1995). In laboratory bioassays, dilute cultures of *Pfiesteria* (ca. 400-2,000 toxic zoospores per mL)

	killed healthy test tilapia in < 20 min. (Burkholder et al. 1995).*Pfiesteria* killed every individual of every finfish and shellfish species tested in culture (e.g., blue crabs, young eastern oysters, littleneck clams, bay scallops, striped bass, hybrid striper, mullet, croakers, spot, eel menhaden, pinfish, founder and largemouth bass) within minutes (Burkholder 1996)
Key impacts selected (critical ecological effects)	Fish kills, fish lesions in waters where *Pfiesteria* occurs.
Exposure Assessment	
Exposure routes and pathways considered	Under specific conditions, such as high nutrient levels and the presence of large schools of fish (e.g., Atlantic menhaden), *Pfiesteria* populations may increase (=bloom), due to the fish secretions and/or wastes, and become toxic (USEPA 1999). *Pfiesteria* then transforms from a cyst in the sediment to 1) a flagellate (=possessing flagella) swimming form that excretes toxins that stun the fish and causes lesions that can be fatal; 2) transforming to an amoeboid form that can feed on fish tissue; and 3) revert back to cyst form in the mud (Gong 1999). While the toxic outbreaks of *Pfiesteria* last only a few hours, lesions and fish kills may persist for days or weeks later (USEPA 1999).
Population(s)/ecosystem(s) exposed statewide	Large fisheries (e.g., menhaden) in the Atlantic region (WMAs 12) and the lower Delaware region (WMAs 17,18). Back bay estuaries all along NJ coast and Delaware Bay shore.
Quantification of exposure levels statewide	Not available
Specific population(s) at increased risk	Large concentration of fish (e.g., menhaden) in waters where there is a potential of *Pfiesteria* to occur in NJ (Figure 1) including the Navesink and Shrewsbury Rivers in WMA #12 in the Atlantic region and in estuarine areas along the shoreline of the lower Delaware Estuary in WMA #17,18.
Quantification of exposure levels to population(s) at increased risk	Not known for NJ waters.
Dose/Impact-Response Assessment	
Quantitative impact-assessment employed	Research on *Pfiesteria* in other states has shown that toxins released by *Pfiesteria* are lethal to finfish in the field and laboratory when cell density is between 250- 300 cells per ml (Heinicke 1999; Burkholder & Glasgow 1997). Experiments have shown cell densities of the organism exceeding 400 cells per mL to be toxic, while cell densities sin excess of 1600 cells per mL without the presence of fish excretia were not toxic (Heinicke 1999).
Risk Characterization	

Risk estimate(s) by population at risk Risk Score = (Severity/Irreversibility) x (Frequency) x (Magnitude)		Score

Assessment of severity/irreversibility 5 - Lifeless ecosystems or fundamental change; Irreversible 4 - Serious damage: • many species threatened/endangered • major community change • extensive loss of habitats/species Long time for recovery 3 - Adverse affect on structure and function of system: • all habitats intact and functioning • population abundance and distributions reduced Short time for recovery 2 - Ecosystem exposed but structure and function hardly affected 1 - No detectable exposure	No detectable exposure. No fish kills due to *Pfiesteria* have been reported in NJ.	1
Assessment of frequency of effect(s) (list definition for each category, e.g., rare = 1/decade) 5 - Often and increasing 4 - Often and continuing 3 – Occasional 2 – Rare 1 - Possible in the future 0 – Unlikely (or 0.1)	Possible in the future.	1

Size of population(s) and/or extent of the State/habitat affected (magnitude) 5- >50% of the State/population impacted 4- 25-50% of the State/population impacted 3- 10-25% of the State/population impacted 2- 5-10% of the State/population impacted 1- <5% of the State/population impacted	If outbreaks do occur, between 1-<5-10% of the state fish population impacted. In terms of human health impacts, about 0.0002-0.0003% (perhaps about 15-25/eight million people).	1
	Total	1
Assessment of uncertainties in this assessment (H,M,L) and brief description	L=Low uncertainty because while results of NJDEP monitoring are not complete, it is not believed that there are specific conditions in NJ waters that promote *Pfiesteria* outbreaks.	
Potential for additional data to result in a significant future change in this risk estimate (H, M, L) and brief description. (Data Gaps; highlight significant data needs)	L=Low because it is believed that while the organism may be present in NJ waters, there are no specific conditions which promote growth and there is no knowledge of its toxic effects at this time. The cause of *Pfiesteria* outbreaks are not fully understood. A high density of fish must be present to trigger the shift of cells to toxic forms. Other factors may contribute to toxic outbreaks by promoting the growth of *Pfiesteria* in coastal waters including warm, brackish, poorly flushed waters and high levels of nutrients (USEPA 1999). Research is needed on the role of nutrients and other factors that may promote toxic blooms (USEPA 1999).	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, ! , =, ≡; where + is improvement), and brief description.	"-" = low potential for changes in risk because NJDEP has already conducted sampling and found *Pfiesteria piscicida* specific DNA at only one site (out of 32 estuarine sites), in the Tuckahoe River samples.	
Potential for catastrophic impacts* (H,M,L) and brief description (*Short-term drastic negative impacts having widespread geographic scope)	L=Low at this point because there are no fish kills in NJ linked to the organism with reasonable scientific certainty.	
Link to other Work Groups (e.g., socioeconomic impacts)	If *Pfiesteria* found in NJ waters, there may be the potential for human health effects and socioeconomic impacts to fisheries.	
Extent to which threat is currently regulated or otherwise managed	Not formally regulated by NJDEP because there have been no reports of the occurrence, but DSRT is conducting monitoring for *Pfiesteria*.. A NJ *Pfiesteria* Contingency plan has been recently completed and may be used by the NJDEP and the NJ Dept. of Health and Senior Services to protect the public and state sampling personnel in the event that a fish kill occur in which there is evidence that *Pfiesteria* may be involved.	
Barriers to restoration	Lack of data on concentrations of *Pfiesteria* in ambient estuarine waters.	
Relative Contributions of Sources to Risk (H,M,L): include any		

information/details on sources	
NJ Primary Sources	*Pfiesteria* may be promoted by high levels of nutrients (Pelley 1998; HABHRCA 1999). Chief sources of nutrient pollution in coastal areas are sewage treatment plants, septic tanks, polluted runoff from suburban landscape practices and agricultural options, and air pollutants that settle on the land and water. Massive fish kills associated with *Pfiesteria* occurred in watersheds heavily polluted by hog and chicken farms and municipal sewage and in aquaculture impoundments (Pelley 1998).
Large business/industry	
Small business industry	
Transportation	
Residential	Potential nutrient pollution source (e.g., septics)
Agriculture	Potential nutrient pollution source
Recreation	
Resource extraction	
Government	
Natural sources/processes	*Pfiesteria* growth may be promoted by warm, brackish, poorly flushed waters in conjunction with human-derived nutrient pollution
Orphan contaminated sites	
Diffuse Sources	
Sediment sinks	*Pfiesteria* may be a natural inhabitant of estuarine sediments
Soil sinks	
Non-local air sources incl. deposition	
Biota sinks	

Issue: Pfiesteria piscicida
Author: Mary Downes-Gastrich
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References:

Atherholt, T. and B. Ruppel. 2000. Research on *Pfiesteria*:: update May 24, 2000. NJ Dept. of Environmental Protection. Division of Science, Research & Technology. (www.state.nj.us./dep/dsr)

Burkholder, J.M. 1996. Unpublished. Facts about *Pfiesteria.* Website: http://www2.ncsu.edu/unity/lockers/project/aquatic_botany/p-abst.html.

Burkholder, J.M. and H.B. Glasgow 1997. *Pfiesteria piscicida* and other *Pfiesteria*-like dinoflagellates in the mid-Atlantic and southeastern United States. Abstract. NCSU (North Carolina State University). Aquatic Botany laboratory Abstracts and Papers on *Pfiesteria piscicidia.* Website: http://www2.ncsu.edu/unity/lockers/project/aquatic_botany/p-abst.html.

Burkholder, J.M., Glasgow, H.B., C.W. Hobbs. 1995. Fish kills linked to a toxic ambush-predator dinoflagellate: distribution and environmental conditions. Marine Ecology Progress Services 124:43-61.

Fox, J.L. 1998. Human illness, fish kills connected to *Pfiesteria* outbreaks. ASM News 64(12): 676-677.

Gong, E. J. Jr., 1999. The Cell from Hell. ABCNEWS.com. website: http://archive.abcnews.go.com/sections/scitech/pfiesteria0919/index.html

HABHRCA (Harmful Algal Bloom and Hypoxia Research and control Act). 1999. National Assessment of Harmful Algal Blooms developed for the National Science and Technology Council Committee on Environment and Natural Resources Task Force on harmful Algal Blooms and Hypoxia. Draft June 1999. Website: http://www.habhrca.noaa.gov/habdraft.html

Heinicke, K.S. 1999. *Pfiesteria* Fact. RIMS (Regional information Management Service). Sheet. Website: http://www.state.nj.us/drbc/rpfeist.htm

NJDEP (New Jersey Department of Environmental Protection). 1999. *Pfiesteria.:* Background information and proposed Contingency Plan. April 1, 1999. NJDEP, Division of Science, Research & Technology.

Pelley, J. 1998. What is causing toxic algal blooms? Environmental Science & Technology News. Jan. 1, 1998. American Chemical Society.

USEPA (U.S. Environmental Protection Agency). 1997. Questions and answers: *Pfiesteria piscicida..* Region III, Philadelphia, PA 19107-4431.

USEPA (U.S. Environmental Protection Agency). 1998. What you should know about *Pfiesteria piscicida.* Website: http://www.epa.gov/owow/estuaries/pfiesteria/fact.html

Issue: Pfiesteria piscicida
Author: Mary Downes-Gastrich
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Statewide Analysis of Threat

Threat = *Pfiesteria piscicida*

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	N/A	N/A	N/A	N/A
Marine Waters	1	1	1	1
Wetlands	N/A	N/A	N/A	N/A
Forests	N/A	N/A	N/A	N/A
Grasslands	N/A	N/A	N/A	N/A
			Total Score	1
			Average Score	0.2

Risk by Watershed Management Region

THREAT = *Pfiesteria piscicida*	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	N/A	Low	N/A	N/A	N/A
Passaic	N/A	Low	N/A	N/A	N/A
Raritan	N/A	Low	N/A	N/A	N/A
Atlantic	N/A	Low	N/A	N/A	N/A
Lower Delaware	N/A	Low	N/A	N/A	N/A
Region/Watershed (secondary)					
Urban		Low			
Suburban		Low			
Rural		Low			

H=high, M=medium, L=low;

Issue: Phosphorus
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New Jersey Comparative Risk Project
Ecological Technical Work Group
Stressor-Specific Risk Assessment

Risk Assessment Framework	Findings
Hazard Identification	
Stressor	**Phosphorus**
Description of stressor	Phosphorus (as phosphate) is an essential nutrient required for plants.
Stressor-specific impacts considered: Biological integrity Biodiversity Habitat/ecosystem health Ecosystem function	Excess phosphorus stimulates plant grown, affecting biodiversity, habitat health, and ecosystem function. There is a substantial scientific consensus that freshwaters are typically phosphate limited, while marine waters are typically nitrogen limited. Thus the primary impact of phosphates is believed to be in freshwaters (USGS, 1999; A Keller 1991; B. Connell, DEP, personal communication). There is, nevertheless, a possibility that some New Jersey estuarine or coastal waters may in the future be found to be affected by phosphates.
Key impacts selected (critical ecological effects)	The eutrophication of New Jersey lakes is the critical impact, because phosphorus has been identified as the limiting nutrient in most freshwaters in New Jersey
Exposure Assessment	
Exposure routes and pathways considered	Phosphates enter NJ lakes from incoming streams, as well as from groundwater, nonpoint surface runoff, septic seepage, and possibly from direct discharges.
Population(s)/ecosystem(s) exposed statewide	
Quantification of exposure levels statewide	Levels higher than 0.1 ppm are very common in New Jersey and occur in every watershed management area. Highest levels are found in the Passaic River (levels range from 0.3 to 0.5 ppm); Hammonton Creek in the Mullica Watershed (0.4 ppm), and in the Rancocas River (lower Delaware region) (0.2 ppm). (NJ DEP 1996)
Specific population(s) at increased risk	Lakes and other impoundments are typically more vulnerable to eutrophication than streams.
Quantification of exposure levels to population(s) at increased risk	
Dose/Impact-Response Assessment Quantitative impact-assessment employed	The national background concentration of phosphates in streams is about 0.1 ppm (USGS, 1999), although many NJ waters have concentrations of 0.05 ppm or less. The phosphorus criteria is set at 0.1 ppm to protect drinking water supplies from potential coagulation problems during treatment and to prevent or reduce eutrophication of surface waters (US EPA 1976; NEPPS). Upstream of drinking water impoundments, the criterion is set at 0.05 ppm. However, no quantitative relationship between the level of phosphates in streams and resulting eutrophication of lakes has been established, although a number of models and guidelines have been developed which take into account flow rates and other physical factors. In lakes, phosphorus concentrations about 0.02 ppm in winter are often used as a definition of eutrophication (US EPA, 1976).

	Most of the work in this area has focussed on total phosphorus as the indicator of eutrophication potential rather than biologically available phosphorus. The models and guidelines are also based on a somewhat subjective judgement as to what is considered a eutrophic lake, based upon Secchi depth, chlorophyll-a concentration, etc. Furthermore, many of New Jersey's "lakes" are, in reality, impounded rivers with detention times and depths out of the range for which these models and guidelines were originally developed.	
Risk Characterization		
Risk estimate(s) by population at risk		Score
Assessment of severity/irreversibility	Eutrophication of lakes changes the lake ecosystem, and is difficult to reverse if it has become well established. Serious damage to ecosystems, with major community change (4), happens occasionally. Less serious damage, with habitats intact but abundance and distributions reduced (3), occurs often.	3
Assessment of frequency of effect(s)	Low level eutrophication effects (severity score of 3) attributable to phosphorus occur often (frequency score of 4). Occasionally (frequency score of 3), more serious eutrophication occurs (severity score of 4).	4
Size of population(s) and/or extent of the State/habitat affected (magnitude)	There are over 100 eutrophic lakes in New Jersey, distributed throughout the state, as shown on the attached map.	4
	Total	48
Assessment of uncertainties in this assessment (H,M,L) and brief description	L. Phosphorus is one of the more widely studied pollutants.	
Potential for additional data to result in a significant future change in this risk estimate (H,M,L) and brief description. (Data Gaps; highlight significant data needs)	L. Phosphorus is one of the more widely measured pollutants in New Jersey waters.	
Potential for future changes in the underlying risk from this stressor (+++, ++, +, 0, , =, where + is improvement), and brief description.	(0). There is potential for increased phosphorus input to New Jersey waters, as a result of increased development (septic systems, sewage treatment, and fertilizer runoff from landscaping). There is also potential for decreased phosphorus input either if regulatory activities were strengthened or if there were reductions in agricultural or residential phosphate fertilizer use.	
Potential for catastrophic impacts (H,M,L) and brief description	L	
Link to other Work Groups (e.g., socioeconomic impacts)	Eutrophication of lakes reduces their recreational value. Phosphorus in drinking water increases water treatment costs.	
Extent to which threat is currently regulated	Fertilizer runoff is not regulated. Phosphates in detergents were banned in the US in 1972.	

Issue: Phosphorus
Author: Thomas
Version: 04/05/00

Barriers to restoration	
Relative Contributions of Sources to Risk (H,M,L); include any information/details on sources	
NJ Primary Sources	Phosphorus is present in sewage treatment plant and septic system effluents and runoff from lawns and agriculture. Phosphorus compounds are also used to reduce drinking water corrosivity by some purveyors.
Large business/industry	L
Small business industry	L
Transportation	L
Residential	M-H (from fertilizer runoff and septic systems)
Agriculture	M-H (from fertilizer runoff and animal wastes)
Recreation	L
Resource extraction	L
Government	M (from sewage treatment plants)
Natural sources/processes	M
Orphan contaminated sites	L
Diffuse Sources	
Sediment sinks	M Phosphates collect in lake sediments
Soil sinks	L
Non-local air sources incl. deposition	L
Biota sinks	M Plant and algae die-off results in release of phosphorus back to the system

Issue: Phosphorus
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References:

Keller, A. et al. 1991. Nutrients and Organic Enrichment. University of Rhode Island. New York Harbor Estuary Program.

NJ DEP. 1996. New Jersey State Water Quality Inventory Report.

NJ DEP. 1998. Environmental Indicators Technical Report. NEPPS. (June).

US EPA. 1976. Quality Criteria for Water.

USGS, 1999. The Quality of Our Nation's Waters: Nutrients and Pesticides. Circular 1225.

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Statewide Analysis of Threat
Threat = Phosphorus (phosphate)

Ecosystem	**Severity Irreversibility**	**Frequency**	**Magnitude**	**Score**
Inland Waters	3	4	4	48
Marine Waters	2	2	1	4
Wetlands	3	4	4	48
Forests	2	0	1	0
Grasslands	2	0	1	0
			Total Score	100
			Average Score	20

Risk by Watershed Management Region

THREAT =	ECOSYSTEM				
Watershed Management Region	Inland Waters	Marine Waters	Wetlands	Forests	Grasslands
Upper Delaware	M	NA	M	NA	NA
Passaic	M	NA	M	NA	NA
Raritan	M	NA	M	NA	NA
Atlantic	M	NA	M	NA	NA
Lower Delaware	M	NA	M	NA	NA
Urban	M	NA	M	NA	NA
Suburban	M	NA	M	NA	NA
Rural	M	NA	M	NA	NA

H=high, M=medium, L=low;